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INTERNATIONAL RESEARCH GROUP ON REFUSE DISPOSAL (IRGRD)

INFORMATION BULLETIN NUMBERS 21-31
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INFORMATION BULLETIN NUMBER 21
August 1964

A NEW METHOD OF DETERMINING DECOMPOSABLE AND RESISTANT ORGANIC MATTER IN REFUSE AND REFUSE COMPOST

By G. Rollé and B. Orsanic, EAWAG Zürich*

1. Behavior of Organic Compounds in the Process of Digestion

Composting, as one of the various means of waste disposal, may be defined as controlled digestion of ground refuse.

In the process of digestion, which actually lasts 3 – 5 months, microorganisms (bacteria and fungi), raised temperatures, oxidative processes, and various other factors lead to the degradation of those compounds that are comparatively readily decomposed. These are first and foremost organic compounds.

In order to study the intricate processes of degradation and the factors influencing the quality of the compost, certain chemical and biological methods are used for the interception of the degradation stages.

It is known that waste contains also organic compounds such as rubber, polyvinylchloride, polyethylene, etc., that can hardly, if at all, be degraded by microorganisms. Other organic compounds of the refuse, as for example, albumins, polysaccharides (cellulose, starch), etc., are readily degraded in the process of composting.

Ultimately, this process leads to mineralization or humification of the organic compounds. Owing to partial mineralization, the total amount of organic material is diminished in the process of digestion, whereby part of the organic matter is converted into the cellular constituents of microorganisms or into humus. In these processes C is lost in the form of CO_2 (mineralization).

2. Resistant and Decomposable Organic Matter

The first aforementioned group of organic matter is designated "Resistant Organic Matter" (ROM), and the second, "Decomposable Organic Matter" (DOM).

These two terms replace the former designations "Inert Organic Matter" (IOM) and "Active Organic Matter" (AOM), terms borrowed from soil-science terminology, but inappropriate in the field of refuse analysis.

It should be emphasized that in practice no clear-cut boundaries exist between ROM and DOM. No organic compound is absolutely resistant, nor is complete breakdown of decomposable organic compounds ever achieved.

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* [EAWAG -- Federal Institute for the Distribution and Maintenance of Water Resources and Purification of Sewage.]

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3. Definition of ROM and DOM

ROM comprises organic compounds that are more difficultly degraded, i.e., requiring

- a longer period of time and/or
- more severe conditions and/or
- are incompletely decomposed as against the other organic compounds designated DOM.

4. Means of Determination

It would be desirable to track down the entire decomposition process of each accurately defined group of organic matter. At present, however, observation is limited to the two above-mentioned groups (ROM and DOM).

It should be pointed out that the analytical methods used in ROM and DOM determination cannot yield absolute values. As earlier mentioned, there are no accurately defined amounts of ROM and DOM.

An analytical method of ROM determination should relate the approximate amount of ROM that remains constant in the course of digestion.

That of ROM determination should relate the approximate amount of DOM converted or degraded in the course of digestion.

If two methods are compared in the determination of ROM, results showing identical values are immaterial; it is essential, however, to record the method that yields constant values throughout the digestion period (see Figure 1).

The content of ROM in refuse was determined until now by the following method (1, 2).

The sample was treated first with dilute hydrochloric acid; the sediment obtained was neutralized with dilute caustic soda; the supernatant fluid decanted, and the sediment further treated, first with cold sulfuric acid and finally with boiling sulfuric acid. The sediment obtained after decantation was assumed to consist of ROM and inorganic acid-resistant components. It was dried at 110° C and incinerated. The amount of ROM was calculated from the difference in weight between the dry and incinerated sediment.

The method proved to have an essential drawback: it was too time-consuming thus preventing extensive serial determinations. It was therefore decided to search for less time-consuming ways of obtaining the information sought, as formulated above.

It was aimed at finding a method whereby the organic matter would reach, in the shortest possible time, the same stage of degradation as it usually attains after several months of digestion.

This aim was also attained with the method described above, though only after several hours of boiling in sulfuric acid. It was therefore attempted to shorten the process by treatment with higher concentrations of acid and other means. As a basis for the new method we adopted the directions given by Walkley-Black (3), according to which degradation is performed with sulfuric acid and potassium dichromate.

In principle, the method consists in treating the specimen with a potassium dichromate solution in the presence of sulfuric acid. A certain amount of the

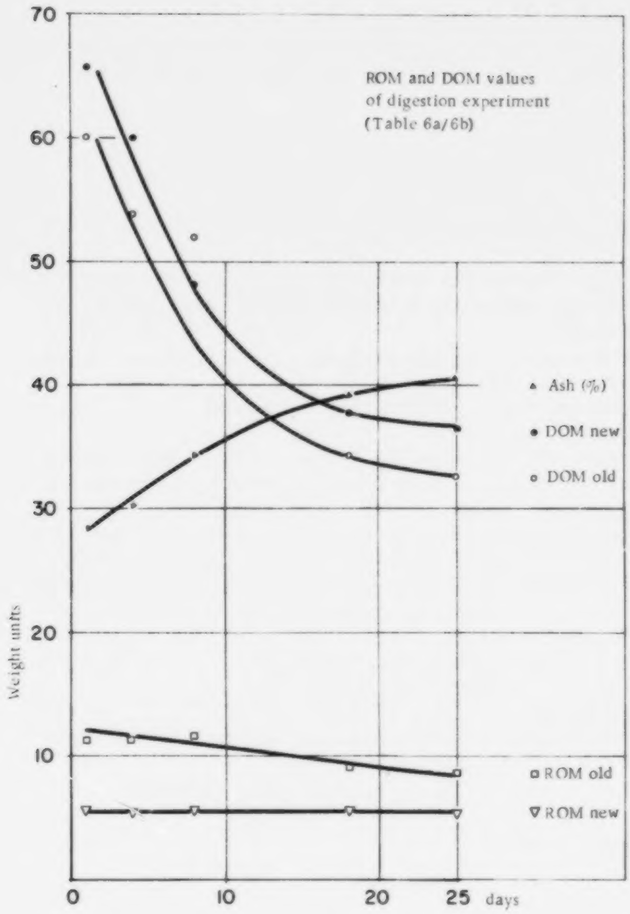

FIGURE 1.

potassium dichromate solution, added in excess, is thereby used up in the oxidation of organic matter. The oxidizing agent left at the end of the reaction is back-titrated with ferrous ammonium sulfate, and the amount of potassium dichromate used up is established. The content of DOM is thus determined.

Assuming that DOM and ROM represent the material lost by combustion, ROM can then be calculated from these values.

As a basis for calculation Walkley-Black assumed that the respective organic matter contained 58% carbon, i. e., that the ascertained content of C should be multiplied by 1.724, in order to establish the amount of the organic compounds (DOM).

It should be added that this factor was ascertained for soils, and it should therefore be used with certain reservations. Nevertheless, all further calculations are based on this factor, since the ROM and DOM values are, as earlier mentioned, only approximate.

5. Experimental

In principle determination of DOM proceeded according to the Walkley-Black method.

In a series of experiments the conditions required according to this method were elaborated for DOM determination in refuse and compost.

These conditions are:

5.1 Optimum size of sample for analysis
5.2 Amount and concentration of H_2SO_4
5.3 Amount and concentration of $K_2Cr_2O_7$ solution
5.4 Temperature of reaction
5.5 Time required for the action of H_2SO_4 and $K_2Cr_2O_7$ on the sample
5.6 Amount of indicator required for a distinct color change
5.7 Concentration of $Fe\,(NH_4)_2\,(SO_4)_2 \cdot 6\,H_2O$ solution

It was attempted to reproduce with the new method, as far as possible, the results obtained with the former technique. The preliminary experiments were performed with a compost sample which, with the old method, yielded the following results:

– loss by combustion	40.5%
– DOM	31.0%
– ROM	9.5%

5.8 Calculation basis

The following formula was adopted for the calculation of all results

$$\mathrm{DOM} = \mathrm{ml} \cdot N\,(1 - \frac{T}{S}) \cdot K \qquad (I)$$

where: ml = $K_2Cr_2O_7$ solution
N = Normal concentration of $K_2Cr_2O_7$ solution
T = ml $Fe\,(NH_4)_2\,(SO_4)_2 \cdot 6\,H_2O$, 0.5 N for back titration
S = ml " " " " for blank test

$$K = \frac{12}{4 \cdot 1{,}000} \cdot \frac{1.724}{0.77} \cdot \frac{100}{g} \qquad (II)$$

where: $\frac{12}{4 \cdot 1{,}000}$ = mg equivalent of C
0.77 = empirical factor after Walkley-Black
g = weighed sample in g
(For g = 0.5000 g, $\underline{\underline{K = 1.34}}$)

On the basis of preliminary experiments the following was established

Ref. 5.1 Optimum size of sample for analysis

A quantity weighing from 0.25 to 1 g was considered. In view of the average amount of organic matter found in refuse and compost, 0.5 g of dried, finely ground material seemed the most suitable.

Ref. 5.2 Amount and concentration of H_2SO_4

As earlier mentioned, it was aimed to reproduce the results obtained with the former technique. The preliminary test (DOM = 31%) showed that the addition of 15 ml of 2 N $K_2Cr_2O_7$ solution according to formula (I) led to the consumption of 13.73 ml ferrous ammonium sulfate. Therefore, an adequate concentration of

H_2SO_4 should be chosen that will allow this consumption of ferrous ammonium sulfate to be attained.

Experimental series: receiving vessel - 15 ml of 2 N $K_2Cr_2O_7$
sample - 0.500 g

TABLE 1. Effect of H_2SO_4 concentration on degradation

H_2SO_4		$Fe(NH_4)_2(SO_4)_2 \cdot 6\,H_2O$		% DOM
ml	conc.(%)	conc.(N)	ml used up	target value = 31 %
20	60	0, 5	40, 96	10, 4
20	66	0, 5	40, 28	10, 5
20	70	0, 5	40, 10	10, 6
20	82	0, 5	29, 88	14, 2
20	84	0, 5	28, 10	15, 1
20	97	0, 5	15, 87	26, 8

These results indicate that more intense conditions of degradation should be established.

Since the concentration of H_2SO_4 could not be raised, 20 ml of the acid continued to be added, but in order to raise the acid concentration in the test mixture, part of the water of the potassium dichromate solution was replaced by concentrated sulfuric acid.

Ref. 5.3 Amount and concentration of the $K_2Cr_2O_7$ solution
It was known from previous experience that the DOM content of compost and, in the main, also of fresh refuse is usually lower than 50%.

The amount of $K_2Cr_2O_7$ solution required depends upon the DOM content (higher DOM content = higher consumption of $K_2Cr_2O_7$).

If 20 ml $K_2Cr_2O_7$ are used and the excess left at the end of the reaction is equivalent to 3 ml of $Fe(NH_4)_2(SO_4)_2 \cdot 6\,H_2O$ (0.5 N), the maximum content of DOM in the sample amounts to 51.59% (according to formula (I)).

Consequently, it was decided to use, as a rule, 20 ml of 2 N $K_2Cr_2O_7$ solution.

In exceptional cases, when the DOM content exceeds 51.59%, the amount of potassium dichromate should be increased (see directions for analysis).

As mentioned in 5.2, a higher concentration of sulfuric acid in the test mixture is reached by preparing the potassium dichromate solution with sulfuric acid as follows:
250 ml H_2SO_4 conc.
98.08 g $K_2Cr_2O_7$ C P
H_2O ad 1,000 ml

Ref. 5.4 Temperatures of reaction
It was necessary to establish whether degradation would reach the desired stage at the temperature produced by the reaction, or whether higher temperatures had to be maintained.

TABLE 2. Effect of reaction-temperatures on degradation at different reaction durations

$K_2Cr_2O_7$, 2 N	H_2SO_4 conc.	Sample	Temp.	Time	ml FeAmS, 0, 5 N	
ml	ml	g	°C	min.	used up	calculated
15	20	0, 5	150	60	1, 28	13, 73
15	20	0, 5	150	120	0, 42	13, 73

FeAmS = Ferrous ammonium sulfate solution

As is evident from the tabulated data, heating of the reacting mixture proves too drastic.

The working temperature adopted was, therefore, the temperature evolved by the reaction.

Ref. 5.5 Time required for the action of H_2SO_4 and $K_2Cr_2O_7$ on the sample

Having established the required conditions, such as

(5.1) Size of sample
(5.2) Amount and concentration of H_2SO_4
(5.3) " " " " " " $K_2Cr_2O_7$
(5.4) Temperature of reaction,

a series of different samples had to be analyzed according to the new method in order to ascertain the time required for the reaction.

TABLE 3. Effect on degradation of reaction duration at the temperature evolved

Sample No.	$K_2Cr_2O_7$, 2N ml	Indicator drops	FeAmS blank ml	ml FeAmS, 0,5 N solution				
				15'	30'	60'	90'	120'
261	20	30	81, 21	8, 70	5, 98	4, 46	-	9, 30
276	20	30	81, 21	10, 52	6, 78	7, 15	-	7, 96
280	20	30	81, 21	52, 30	51, 85	51, 77	-	53, 62
288	20	30	81, 21	35, 80	32, 84	30, 70	33, 20	32, 35
289	20	30	81, 21	50, 41	50, 18	51, 36	51 40	50, 98
300	20	30	81, 21	8, 68	8, 31	8, 89	11, 90	7, 00
310	25	30	101, 00	-	1, 50	1, 70	-	2, 02

Although variation of reaction time displays certain fluctuations no significantly enhanced degradation was recorded at prolonged reaction.

Consequently, the reaction time adopted was limited to one hour as in the preliminary tests.

Ref. 5.6 Amount of indicator required for a distinct color change

The amount of indicator added to the titrating solution varied from 10 to 30 drops. The color change was most distinct with 30 drops, and this amount was forthwith adopted.

Ref. 5.7 Concentration of $Fe(NH_4)_2(SO_4)_2 \cdot 6\ H_2O$ solution

At low DOM content a large amount of ferrous ammonium sulfate is used up. Higher concentrations of the reagent would be desirable, but since its low solubility prevents preparation of Normal or 2 N solutions, 0.5 N concentrations have to be used.

The conditions required were established with the aid of these preliminary tests. Consequently, the amount of decomposable organic matter (DOM) in refuse and compost is determined as follows.

6. Method for Determination of Decomposable Organic Matter (DOM)

6.1 Reagents

2 N solution of potassium dichromate : 98.08 g of $K_2Cr_2O_7$ CP are dissolved while heating in 400 - 500 ml H_2O. After quick cooling, 250 ml conc. H_2SO_4 CP are

carefully and slowly added under constant agitation (while the vessel is immersed in ice water). H_2O is added to make up one liter.

Sulfuric acid : H_2SO_4 conc. CP minimum 96%
Phosphoric acid : H_3PO_4 conc. CP
Sodium fluoride : NaF CP

Diphenylamine indicator: to 20 ml H_2O, 100 ml of concentrated H_2SO_4 CP are carefully added; 0.5 g diphenylamine are dissolved in this mixture.

0.5 N ferrous ammonium sulphate solution: to 780 ml H_2O, 20 ml of conc. H_2SO_4 CP are carefully added. In this mixture 196.1 g $Fe(NH_4)_2(SO_4)_2 \cdot 6H_2O$ are dissolved and the volume made up with H_2O to one liter.

6.2 Procedure

The 0.500 g sample is weighed in a 500 ml Erlenmeyer flask. From a buret of potassium dichromate solution are accurately added 20 ml and thoroughly mixed with the sample. Immediately, 20 ml sulfuric acid are carefully added drop by drop under constant shaking. The mixture is kept for exactly one hour and shaken occasionally. The volume is made up with H_2O to approximately 200 ml.

The following are added in the sequence listed:

- phosphoric acid 10 ml
- sodium fluoride 0.2 g
- indicator 30 drops

Each addition is followed by thorough mixing.

The excess of potassium dichromate is back titrated with the ferrous ammonium sulfate solution. Addition of the indicator imparts to the mixture a dirty brownish green hue. In the course of titration the color changes through green-blue to blue. At the end point this blue color is changed by the addition of one drop into pure green.

If the mixture becomes green-blue or blue immediately after addition of the indicator, the end point of titration is near.

The amount of potassium dichromate solution required for oxidation depends upon the DOM content. Addition of 20 ml potassium dichromate might prove insufficient in analyses of fresh material (fresh refuse, fresh refuse admixed with sewage sludge). In such cases 25 or 30 ml should be added. This is already indicated at the time the loss by combustion is determined. The amount of 20 ml potassium dichromate is adequate up to a loss by combustion of approximately 55%. In border-line cases the green color may appear directly upon addition of the indicator; titration should then be repeated with a larger initial amount of potassium dichromate.

6.3 Calculation

$$\mathrm{DOM} = \mathrm{ml}\ \mathrm{N}\left(1 - \frac{T}{S}\right) \cdot 1.34 \qquad \text{(III)}$$

where: DOM = decomposable organic matter in percent of dry-matter weight
ml = ml of potassium dichromate solution
N = normality of potassium dichromate solution
T = ml of ferrous ammonium sulfate solution for back titration
S = ml " " " " for blank test

6.4 Conversion to wet matter

$$\frac{\mathrm{DOM} \cdot \mathrm{DM}}{100} = \mathrm{DOM} - \mathrm{WM} \qquad \text{(IV)}$$

where: DM = dry matter of wet sample, in %
DOM – WM = DOM content in percent of wet-matter weight.

6.5 Conversion to weight units (WU)

(based on 100 WU initial material)

It is assumed that in the course of digestion the quantity of ash remains constant, whereas the amount of organic components is reduced by decomposition.

If the ash percentages of the sample (n) and of the initial material are known, all results may be converted and compared with the initial material.

The calculation of weight units is important when serial tests are performed from the same material in the course of digestion (see Table 6b).

$$\frac{A}{A_n} \cdot DOM_n = DOM - U \qquad (V)$$

where: A = ash content of initial material in % of DM weight
A_n = ash content of sample (n) in % of DM weight
DOM_n = DOM content of sample (n) in % of DM weight
DOM - U = DOM content of sample (n) in WU, calculated for 100 WU of initial sample.

7. Determination of Resistant Organic Matter (ROM)

The resistant organic matter comprises those components of the refuse and compost that are degraded with difficulty, if at all, such as rubber, PVC, polyethylene chloride and other synthetic material.

Quantitatively, ROM is referred to that amount of loss by combustion that is not degraded according to the method described in 6.

Assuming that DOM and ROM represent the loss by combustion, ROM can be calculated as follows.

7.1 Calculation

$$L - DOM = ROM \qquad (VI)$$

where: L = loss by combustion.

7.2 Conversion into wet matter

$$\frac{ROM \cdot DM}{100} = ROM - F \qquad (VII)$$

where: ROM - F = ROM - content in % of wet-matter weight.

7.3 Conversion into weight units

$$\frac{A}{A_n} \cdot ROM_n = U \qquad (VIII)$$

where: ROM_n = ROM – content of sample (n) in % of DM weight
ROM – U = ROM – content of sample (n) in WU, calculated for 100 WU of initial sample.

8. Comparative Tests

The described method was tested with different samples.

DOM and ROM were parallelly determined with both the old and the new method.

TABLE 4. Differences revealed between the new and the former method in different material tested

Sample No.	Material	$K_2Cr_2O_7$ 2 N ml	Indicator drops	$Fe(NH_4)_2(SO_4)_2 \cdot 6H_2O$ 0, 5 N			ROM %		Difference %	Loss by combustion %
				ml for blank	ml titrated	ml calculated	old method	new method		
261	Compost	20	30	81, 21	4, 46	–	9, 07	12, 03	+ 2, 96	62, 68
276	"	20	30	81, 21	7, 15	9, 55	8, 43	6, 75	- 1, 68	55, 63
280	"	20	30	81, 21	51, 77	50, 60	7, 01	7, 21	+ 0, 20	26, 71
288	"	20	30	81, 21	30, 70	33, 80	9, 50	6, 93	- 2, 57	40, 50
289	"	20	30	81, 21	51, 36	51, 90	8, 30	7, 40	- 0, 90	27, 10
300	Aerated Heaps	20	30	81, 21	8, 89	22, 80	14, 70	5, 26	- 9, 44	53, 00
310		25	30	101, 00	1, 70	10, 85	12, 24	6, 11	- 6, 13	71, 98

TABLE 5. Behavior of different pure materials in the process of oxidation with potassium bichromate

Sample No.	Material	$K_2Cr_2O_7$ 2 N ml	Indicator drops	$Fe(NH_4)_2(SO_4)_2$ 0, 5 N		ROM %	
				ml for blank	ml titrated	new method	calculated**
1	0, 5 g Polyethylene (PA)	10	30	40, 3	23, 88	89, 10	-
2	0, 5 g Rubber (G)	10	30	40, 3	29, 15	92, 6	-
3	0, 5 g Polyvinyl chloride (PVC)	10	15	40, 3	34, 95	97, 4	-
4	0, 5 g Filter paper (P)	40 *	30	161, 0	19, 33	5, 7	-
5	0, 25 g P + 0, 25 g PA	20	30	80, 6	8, 48	52, 05	47, 40
6	0, 25 g P + 0, 25 g G	20	30	80, 6	7, 21	51, 2	49, 15
7	0, 25 g P + 0, 25 g PVC	20	30	80, 6	8, 50	52, 05	51, 55
8	0, 168 g P + 0, 168 g PA + 0, 168 g PVC + 0, 168 g G	20	30	80, 6	20, 50	70, 25	71, 20

* Double amounts of all reagents added: 40 ml $K_2Cr_2O_7$, 2 N; 40 ml H_2SO_4, conc.; 20 ml H_3PO_4, conc.; 0, 4 g NaF ad 400 ml H_2O

** Calculated for example: $\frac{P+PA}{2} = \frac{5,7+89,10}{2} = \frac{94,80}{2} = 47,40$

The results obtained with both methods coincided rather satisfactorily in samples 267, 276, 280 and 289.

Significant differences between the two methods were revealed in samples 300 and 310. These samples originated from heaps artificially created in the course of digestion. It seems that the conditions thereby established in the material led to enhanced oxidation with potassium dichromate. This might explain the lower values obtained with the new method, since this effect could not be detected with the former method (boiling in sulfuric acid).

This finding indicates that artificial aeration in the course of digestion strongly influences the oxidative processes; this influence, although expected has, so far, remained obscure.

This problem needs further investigation.

Additional tests of the method were performed with various samples of pure, defined, single and mixted materials. The results are summarized in Table 5.

The experiments with pure materials show that, as expected, relatively highly resistant material may be attacked, whereas filter paper, a seemingly readily decomposable material, is not completely disintegrated.

9. Observation of Degradation in the Course of Digestion by DOM-and ROM-Determinations with Both Methods

Fresh refuse obtained from a plant equipped with a hammer mill perforated plastic baskets (4). The digesting material was turned at certain intervals and wetted, when necessary. In this way the water content was never lower than 45%. The raw samples withdrawn at the same time were representative average samples.

In all instances, the raw samples were dried in conjunction with water-content determination and finely ground.

All results were calculated as dry matter (DM).

TABLE 6a. Results of a digestion-test analysis

Sample No.	Time of digestion in days	Water %	DM %	Loss by combustion %	Ash %	ROM %	
						old method	new method
1	1	58. 6	41. 4	71. 5	28. 5	11. 4	5. 64
2	4	54. 4	45. 6	69. 6	30. 4	12. 3	5. 58
3	8	50. 2	49. 8	65. 4	34. 6	14. 6	6. 99
4	18	48. 7	51. 3	60. 5	39. 5	12. 8	7. 95
5	25	52. 1	47. 9	59. 3	40. 7	12. 6	7. 18

TABLE 6b. Results of the same digestion-test analysis converted into weight units

Sample No.	Day	Weight units lost by combustion	ROM in weight units		DOM in weight units	
			old method	new method	old method	new method
1	1	71. 5	11. 4	5. 64	60. 1	65. 9
2	4	65. 3	11. 5	5. 28	53. 8	60. 0
3	8	53. 9	11. 8	5. 76	52. 1	48. 1
4	18	43. 6	9. 2	5. 74	34. 4	37. 9
5	25	41. 6	8. 8	5. 04	32. 8	36. 6

The composting experiments in plastic baskets show that:

the ROM-content determined with the old method was not constant, since it diminished in the course of digestion. With the new method, these values remained constant throughout.

The values obtained with the old method were seemingly too high at the start because they comprised some of the ROM that was subsequently degraded.

10. Conclusions

A new method was elaborated for determination of decomposable organic matter (DOM) in refuse, and in compost prepared from refuse and sewage sludge.

The method consists in the fast degradation by drastic means ($K_2Cr_2O_7$; conc. H_2SO_4) of the decomposable organic matter (DOM). Its essential advantage is the short time required per analysis.

As evident from the numerous experiments reported, the results obtained with this method would appear to be reliable.

The new method elaborated for the determination of DOM enables calculation of the amount of resistant organic matter (ROM).

Bibliography

1. Springer, U. Mitt. Verband deutscher landw. Untersuchungs - und Forschungsanstalten, 1, 6/1954.
2. IAM (IRGRD). Internationale Arbeitsgemeinschaft für Müllforschung. Methoden zur Untersuchung von Müll- und Müllklarschlamm-Kompost (Methods for the Analysis of Refuse and Refuse-Sewage-Sludge Compost). p. 7 (Out of print).
3. Walkley-Black. Oxidable Matter by Chromic Acid with H_2SO_4 - Heat of Dilution. In: Jackson, M. L. Soil Chemical Analysis. – Prentice Hall Inc. N.J., p. 219. 1958.
4. IAM (IRGRD) Methoden zur Untersuchung von Müllklärschlamm-Kompost (Methods for the Analysis of Refuse and Refuse-Sewage-Sludge Compost). – p. 28 (Out of print).

SIMULTANEOUS UTILIZATION OF URBAN REFUSE FOR COMPOSTING AND BIOLOGICAL HEATING

By Dr. Stefan Terts (Horticultural Research Institute, Budapest)

Introduction

The composting of urban refuse aims also at rendering the refuse harmless.

The humus and mineral nutrients in this compost can be constructively utilized in agriculture and horticulture, where humus fertilizer has always been in short supply. The compost prepared from urban waste may thus prove rather valuable. For this reason composting of urban waste has developed into a world-wide practice.

In addition to supplying fertilizer and neutralizing untoward effects of urban refuse, composting should be valued also for the useful heat energy released in the process. The heat energy might also be utilized for biological means of gas production. This, however, has the drawback of requiring a rather expensive installation. The heat energy contained in the organic matter of urban refuse can also be indirectly utilized, through its biological heat production. In Denmark and

Holland, part of the urban refuse is used primarily for this purpose, i.e., the prepared fresh refuse is used as underheating material in hotbeds. This utilization is also relatively expensive as it involves preliminary preparation and transport of the material.

Experimental

I have been engaged in systematic composting of urban refuse since 1957. The material collected in the months of June and July of the year 1957 was heaped and covered with a layer of turf. Heat evolution from the fresh material started the following day, and temperatures remained high from then on. The temperature of the material heaped on the 4 July (10 Kuka-car loads) reached 40° C even three months later (11 October). Since it was rather dry, we wetted it and turned it over. The temperature rose first to 70° C, and fell gradually, but was still at 40° C on 21 December, when it was again wetted and turned over, and the temperature continued to rise even above 50° C.

On 22 January 1958, i.e., after 6½ months, the temperature of the refuse heap was 50° C; at this stage hotbeds were set up on the refuse heap, filled with soil and planted with onions. Three weeks later we obtained marketable spring onions. After onions, cabbage was sown and at the end of May we had seedlings ready for planting.

In the summer of 1958 more material was brought in and heaped and, at the end of January 1959, after previous wetting and turning over, hotbed frames were set up. Under the glass frames red pepper, tomatoes, radishes, lettuce, onions and other seedlings were grown. Heat evolution was very satisfactory, and the vegetables and seedlings grew successfully. Following these small-scale tentative experiments, 240 hotbeds were set up in April and March, 1960, on refuse heaps erected in the summer of 1959, and then turned over. The hotbeds consisted of 6 units of 40 double frames in which lettuce and tomatoes or red-pepper were grown.

In the previous two years the experiment was carried out in simple hotbeds. The refuse heap was approximately 2.8 m wide (see Figure 1). In the experimental pilot plant erected in 1960, double frames were set up in single rows, on heaps 5,8 m wide, and in double rows on heaps 10 m wide. Watering was carried out with warm water obtained from tin barrels sunk into the heaps (Figures 2 and 3). The vegetable and seedling growing yielded most satisfactory results.

In the spring of 1961, after three years of experiments, a large scale (3,000 hotbeds) enterprise was set up by two agricultural cooperatives (in Budapest and Szendendre) for the purpose of this double utilization of refuse heaps. The possibility of doubly utilizing the refuse heaps has been demonstrated in this pilot plant operation, but at the same time it became clear that in order to comply with public health regulations, it could be carried out only within the framework of an utilitarian undertaking.

Waste utilization by me[illegible] of hotbed-composting plants

As has been established, hotbeds can be heated on the refuse heaps by fermentation heat. With this method the heat evolved during composting may be directly utilized. It should be mentioned however, that winter garbage is rich in ash and poor in moisture and organic matter. Therefore, only summer garbage is suitable for composting and biological heating. The composition of the Budapest refuse is summarized in Table 1 (after J. Tóth).

FIGURE 1. Tomato seedlings on a refuse heap

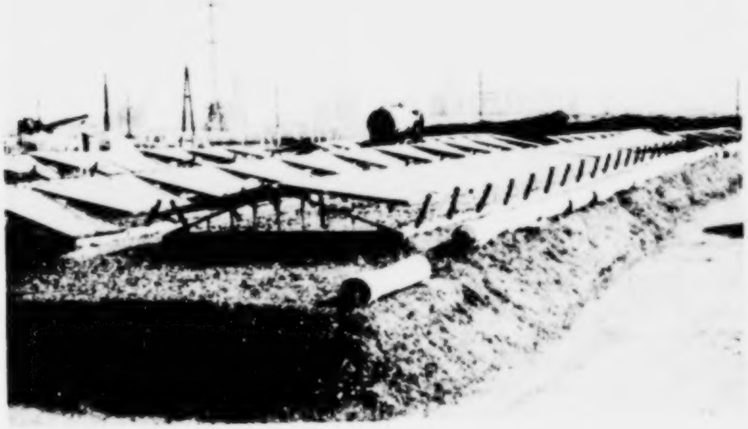

FIGURE 2. Double frames arranged on the prismatic refuse heap

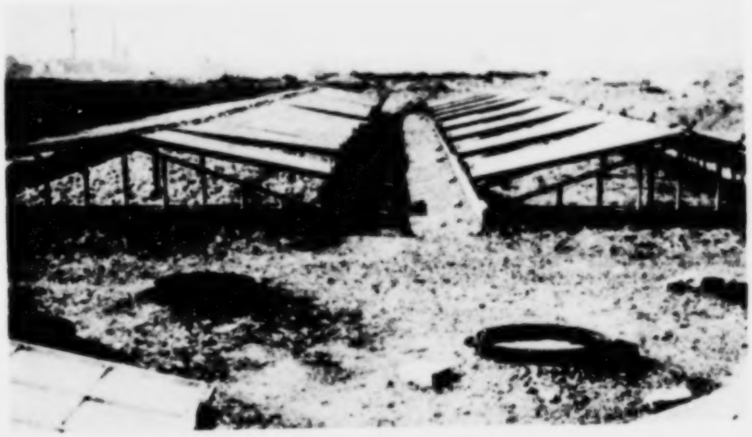

FIGURE 3. The water in the tin barrels sunk into the prismatic heap is also heated

I have termed the double utilization for composting and heating "utilization by hotbed-composting plant." The collected garbage should be heaped in the area of the composting plant according to plan. For single rows of double frames the heap should be 5.8 m wide; for double rows - 10 m. The appropriate length of the heap is 63 m, but sufficient space should be left at the end of the double frame units for placing the windows.

TABLE 1. Average composition of houshold refuse collected in Budapest (after J. Tóth)

Month	Moisture %	Humus %	Organic matter from refuse in %	
			moist	dry
January	10	70	20	22
May	44	26	30	54
September	70	10	20	66

The heaps should be 100 - 120 cm high. The fresh refuse should be arranged in the desired shape when discharging, and the heap covered immediately with a layer of rich soil, turf or compost, since the odor of the already fermenting waste attracts flies. When covered, the heaps are odorless and fly-free and need not be treated with insecticides. The moist heaped material begins immediately to decompose and its temperature soon rises to 70°C. Heat evolution gradually drops.

The heaps should be turned over four to six weeks prior to preparation of the hotbeds. Before turning over, the heaps should be watered since the material is not moist enough (excepting summer-refuse rich in melon remnants). Taking into account that the weather might be very cold at the time the heaps must be turned over, it is expedient to water those heaps that require additional moisture, before the frosts set in. The material is both mixed and aerated by being turned over, and at the same time solid waste (tin, glass, wood, etc.) can be removed. Heat production sets in vigorously again after turning over. Meanwhile the hotbed frames are set up and filled with earth. The composition and thickness of the earth layer depends upon the amount of heat production required by the plants. Onions, radish, lettuce, etc., may be succeeded by cultivated plants.

The economic value of the hotbed-composting plant

Utilization of urban refuse for biological heating in the form of hotbed-composting-plants is valuable only if nurseries can be established in or near towns. Since the material must be handled under strict observation of the sanitary regulations, this mode of waste utilization should be based on utilitarian plants. By double utilization of the refuse, compost is gained within 12 - 15 months, calculated from the time of collection to the end of production. In general, complete digestion cannot be guaranteed without watering and turning over. The cost of composting, however, is increased considerably by watering and turning over. The additional expenses are not justified for the compost alone, but the heating value gained reduces the cost of composting.

So far, the gains from compost production alone cannot be unequivocally proved. This infers that composting, for the sake of compost production, is not necessarily remunerative. The handling expenses seem, however, more reasonably divided when evaluated from both aspects: as a cheap means of sanitation, and as a process supplying the compost and heat energy required for farming. For each one of these purposes alone composting would be too expensive.

Hence, refuse processing in hotbed-composting-plants has the following advantages.

1. Complete digestion of wastes (with their simultaneous neutralization), i. e., high compost yields, together with
2. little residual matter. This is not a negligible advantage if we take into account that the discharge sites remain serviceable for longer periods of time.
3. Utilization of the heat energy for biological heating.
4. It does not require special investments beside those imposed by composting alone (especially the mechanical sifting and the mechanical turning over which, so far, has remained problematic).
5. The need for preliminary selection is completely eliminated, except for utilizable wastes.

The compost can be used in hothouses (for both vegetables and ornamental plants) as well as in the maintenance of parks, orchards, vineyards and general gardening. A permanent hotbed-composting-plant can use on the spot part of the compost produced for covering the fresh refuse heaps, i.e., for the production of soil required for hotbed cultures, while the rest can be sold.

The total summer refuse collected in Budapest can be converted into approximately 200,000 tons of compost. These may supply the organic fertilizers required yearly for an irrigated area of approximately 116,000 ha, supplying at the same time biological heating for 100,000 hotbeds (187,000 m^2). The refuse collected from towns of this size could be converted into a significant source of energy for cultivation or nurseries of early vegetables, or for both.

If the entire refuse of Budapest were utilized, the yearly amount of garden products would be approximately as follows:

2 million pieces early garden lettuce
early cabbage seedlings for an area of 1,450 ha
early tomato seedlings for an area of 2,088 ha
early red-pepper seedlings for an area of 580 ha
750,000 kg early cucumbers, and
7.5 million pieces early green peppers.

Evidently, other crops can be planned for cultivation in conjunction with the hotbed-composting-plants. Conversion of the entire amount of summer refuse of Budapest or of other large towns is probably impossible. But, as already demonstrated, conversion of only 50% would transform the material we consider refuse into an important factor for both town supply and the national economy.

Conclusions

1. Compost heaps may serve for heating hotbeds set thereon if the refuse collected in summer is piled up in suitable heaps, covered with earth or similar material, turned over prior to planting and, if necessary, watered.
2. Refuse conversion by the hotbed-composting-plant system offers suitable conditions for complete digestion of the refuse, i.e., sufficient time, water for moistening, aeration by turning over. These provide for maximum production and a minimum of residual material.
3. The obnoxious material is made absolutely harmless. The expenses are divided between the compost supplied for agriculture and heat energy, so that for each one of these factors relatively lower expenses are involved.

THE REFUSE COMPOSTING PLANT IN HINWIL, THE HIGHLANDS OF ZURICH

By Ing. W. Dolder, Rüti ZH

The construction and operation of the refuse reclamation plant in Hinwil shows that it is possible to collect and dispose the solid waste of a rather large region in a perfectly sanitary manner,and to convert it into humus fertilizer at relatively low cost. Thereby, valuable material is gained from the point of view of the national economy, for gardening, viniculture, silviculture and other agricultural branches that are adopting, for the time being, an attitude of reserve. The operating expenses of the composting plant in Hinwil are lower than for incineration, even when the compost cannot be disposed of and must be stored on appropriate sites.

The first steps in this direction were undertaken at the beginning of the fifties by the farsighted authorities of the Zurich Highlands, which comprise a number of average-size and larger communities. A conference on refuse incineration organized by the local authorities in Uster, in 1956, was attended by representatives of numerous communities. Even then it was evident that this problem cannot be satisfactorily solved by any single community. In 1957 the health authorities of several highland communities visited the composting plant in Chur, and the incineration plant in Davos, whereupon a commission was elected for the study of intercommunal refuse-disposal problems. A wider assembly was convened in May 1958 and attended by representatives of cantonal authorities, the EAWAG, and interested business establishments, in order to discuss the possibilities of incineration and composting, taking into account the conditions prevailing in the highlands.

In January 1959, a society was established for financing the required investigations, elucidations and planning of refuse reclamation in the Zurich Highlands. This society included 14 of the Zurich communities and two of the St. Gall Canton with a total population of 86,000 inhabitants.

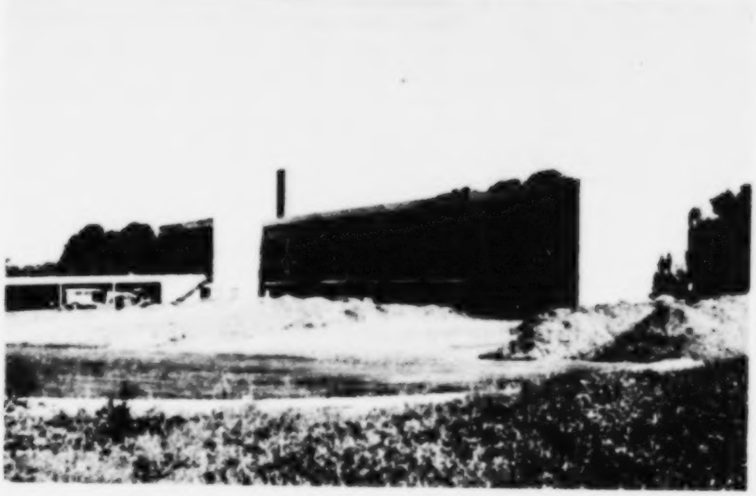

FIGURE 1. The refuse composting plant at Hinwil in the Zurich Highlands

Selection of method and planning

As the first detailed inquiries and examinations of the regional conditions were reported, leading personalities of the association concluded, on the basis of local and foreign experience, that only an incineration plant could be considered, in view of the above-mentioned number of inhabitants. Repeated and thorough discussions with the Swiss establishment, which was then the potential equipment supplier, revealed, however, a different picture. According to the then known system, apart from larger towns, incineration appeared to be advisable only if the waste heat would be in demand throughout the year. This is all the more decisive for towns with less than 150,000 inhabitants, since permanent maintenance of the required incinerating temperature demands, at least occasionally, additional heating with fuel oil. Whether the systems more recently introduced on the market have changed the situation, remains to be seen.

As it became clear that in the conditions of the Zurich Highlands the problem could be solved only with the aid of composting, all existing procedures of this kind were thoroughly examined in both local and foreign plants. Numerous experiments were carried out under the direction of EAWAG. After mature consideration it appeared that the combined procedures of Bühler, Uzwil, and "Dano" A. G., Copenhagen, were the most promising. The project suggested in the year 1960 was the first to be based on this combination. The size of the works was established on the basis of 100,000 inhabitants (i) with a specific yield of 530 g/i/day. The estimated cost amounted to 2,730,000 francs. The project was approved by the respective communities in the spring of 1961, and construction started in the fall.

Organization

In the spring of 1961, the number of interested political communities had grown to 18 and these formed a company for the construction and operation of the plant. The responsible authority of this company consists of a managerial commission with two representatives from each communal authority. The executive organ is a seven-man production committee. The collective reclamation plant imposed a strictly organized system for collection of the refuse, and for its transportation to the central plant. Transportation by the Ochsner system with separate solid-waste removal was introduced in all communities for the inhabitants concerned. In this connection, certain instructions and limitations were unavoidable. An Ochsner wagon that transports the refuse twice a week can service 12.000 - 15.000 inhabitants. The communities are grouped in separate units, the distances varying from 2 to 17 km, with an average transportation distance of 9.85 km. It was therefore decided to use trucks with adequate capacity.

Transportation was assigned to eight different contractors with a total of 10 trucks. As the time required for the refuse collection varies according to the structure of each settlement, the compensation is correspondingly proportional. The transportation costs are calculated in the spirit of collective solidarity, according to the tonnage delivered, irrespective of the distance.

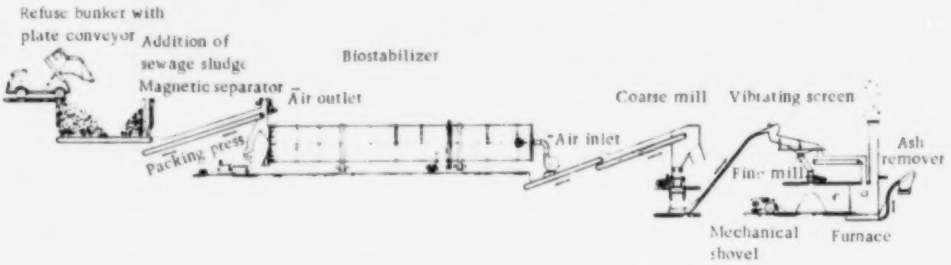

FIGURE 2. Diagram of the composting plant

The plant, combination of two procedures

The household refuse and the bulky refuse are separately collected and transported, and tipped into separate bunkers. The refuse is transferred by a conveyor belt directly into the so-called biostabilizer, a slowly-rotating drum, 28 m long and 3.50 m in diameter. The solid waste is crushed in a hammer mill and also carried by the conveyor into the drum. Metal pieces are electromagnetically removed beforehand from both components. Fluid or dried sewage sludge is added to the drum in the beginning. An ingenious ventilator system takes care of good aeration of the drum. After a while vigorous aerobic fermentation sets in, accompanied by a considerable rise in temperature. The volume of the mixture drops to approximately one third of the initial volume. Bacterial fermentation converts the organic matter into humus compounds. The high temperatures, reaching 60°C, ensure extensive annihilation of pathogenic agents, although the latter are not removed by the heat alone, but mainly by the antibiotic effect of the microbial metabolites.

The preliminarily digested compost passes after two or three days into a hammer mill, where it is comminuted. After repeated electromagnetic elimination of the residual metal parts, the compost is conveyed to a vibrating screen. The screen residues, consisting of textiles, synthetic material, rubber, etc., are incinerated in an oil-fired furnace. The screened material is again passed through a mill, the double break-roll, so as to rid it of glass fragments, and then transferred by the conveyor belt to the composting site. There it ripens within 3 - 4 months, being twice turned over during that time, whereupon the temperature again rises to 70°C. The compost is turned over and loaded by two mechanical shovels.

The spent air is pressed into the soil for filtration. The metal parts removed by the electromagnet are packaged by a hydraulic press.

The mechanical installation is enclosed in a hall built of prefab concrete units. The foundations of the machinery and installations are separated from the hall by gaps thus preventing undesirable vibrations. The soundproof walls make for tolerable working conditions. Situated in the building are also the switchboard, transformer station, office, rest room, WC, showers, and garage. The buildings provide only for the strictly necessary. Any trace of luxury fittings has been consistently avoided. The planners are guided by the principle that in view of the imminent task of extensive construction of public buildings any investment in construction of utilities beyond the absolute necessary is simply unjustified.

The asphalted composting place, extending over an area of about 7.500 m², has an adequate drainage system, the precipitations being channeled into a separate screening installation. The compost carried away by the waters is thus retrieved.

The entire site covers an area of about 13,000 m²

The plant personnel at present consists of a general manager, a foreman and five workers. Initially, the plan allowed for a total of five employees. The manager is in charge of the compost sales and advising the clients, besides the indispensable administrative tasks.

First operation experiences

The composting plant was opened at the beginning of August, 1963. The first five months were spent in experimental operations and running in. During that time adjustments were made in the installations, and the difficulties arising from the heterogeneous material to be processed were eliminated. The ever increasing amount of synthetic material and textiles is even now a source of periodic disturbances in production, which are now easily removed by the experienced personnel. The machinery supply company had to make certain mechanical modifications and final adjustments, which was to be expected considering the newness of the works and their extent.

According to local and foreign experts the quality of the compost is excellent. There is also a good market for the compost. It is expected that after an introductory period of one to two years the entire production will be sold easily at 8 to 10 Fr. per ton, or 5.50 to 6 Fr. per m³.

The number of participating political communities has meanwhile increased to 23, with approximately 100,000 inhabitants.

The amount of solid waste surprisingly is much lower than expected.

The following average values were calculated for the household refuse and solid waste collected during the first eight months:

	Yield in kg per inhabitant/year		
	Houshold refuse	Solid waste	Total
Semiurban communities	130	37	167
Rural	102	24	126
Mean value	120	33	153

The average yield per inhabitant amounts to 420 g per day.

Transportation or daily processing on an average amounts to 45 t refuse, 12 t solid waste, and for the time being, 8 to 10 t sewage sludge containing 90% water. On very busy days the yield may reach 55 t refuse, and 26 t solid waste, which must be processed within 8 hours.

The total yearly yield will be approximately 11,500 t household refuse, 3,200 t solid waste, 2,200 t sewage sludge containing 90% water. This produces 11.000 t compost, 1,700 t residue for incineration, and 800 t iron scrap. The volume of the milled, preliminarily digested compost is at the time of heaping 0.4, and two months later, 0.75. It is intended to add to the sifting residue discarded oil from garages and refineries in order to lower the incineration costs, and to dispose at the same time, of part of this undesirable waste.

At the present time of abundance, the slightly impure scrap-iron cannot be marketed in Switzerland. It must be transported and stored in pits. Bulky scrap-iron is separately collected and disposed of through scrap-iron dealers.

The organization of the household refuse and solid-waste collection service has stood the test. In the beginning there were occasional complaints by indignant housewives when the transport personnel left behind certain wastes, in accordance with the strict separation of household refuse and solid waste.

Construction and operation costs

The construction of the plant coincided with a boom in the building trade, which was accompanied by the well-known massive price increase. Since 1960, when the building costs were estimated, the price of certain labor types has increased by 25% and more.

The building costs of the complete plant amount to approximately Fr. 3,150,000, thus exceeding the original estimate by Fr. 420,000. Of this amount Fr. 295,000, or 10.8% are accounted for by the construction price increase, and 125,000 Fr. were spent on extensions and equipment decided upon later. The quota per inhabitant of the participating communities (on the basis of December 1960) amounts to Fr. 32.15 as against the estimated Fr. 29. On the basis of a cautious estimate made in 1964, the running cost per inhabitant after deduction of the income expected from compost sales, will amount to about Fr. 2.60.

Accordingly, the price per ton of processed refuse amounts, for the time being, to Fr. 17. Provided the entire amount of compost produced can be marketed, the cost per inhabitant may be reduced in future to Fr. 2.15, or about Fr. 14 per ton. The cost of transportation (collection and transport service) per inhabitant is about Fr. 6.40. The increased purchase cost of the vehicles and the higher salaries of the servicing personnel definitely also affect these expenses very considerably.

ANNOUNCEMENTS OF THE SECRETARIAT

Symposia on economic problems of waste and waters will again take place at the Technical Institute in Stuttgart, in the winter semester 1964/1965.

Symposia on refuse disposal techniques will be organized in cooperation with the study group on Communal Refuse Economy (AkA) and the Society for Car Park and Town-Cleaning Work (VkF), and will deal particularly with methods of refuse disposal, their specific advantages and drawbacks, their limitations and cost. The discussions and lecture will occupy the whole day.

The half-day symposia on the water economy in settlements are intended for discussions on the formation of decay spaces and treatment of sewage sludge.

The following symposia are planned:

20.11.1964 from 10.00 to 17.30 hr: 5. Refuse disposal techniques "Selection of methods of refuse disposal"
11.12.1964 from 14.00 to 18.00 hr: 39. Water economy of settlements: "Structural problems concerning digestion chambers"
15. 1.1965 from 10.00 to 17.30 hr: 6. Refuse disposal techniques:"Collection and transportation of household refuse and of solid waste"
5. 2.1965 from 14.00 to 18.00 hr: 40. Water economy of settlements:"Means of dewatering sewage sludge"
26. 2.1965 from 10.00 to 17.30 hr: 7. Refuse disposal techniques:"Selection of sites and protection of landscape in relation to refuse disposal"
"Special aspects of controlled tipping."

The exact program with the respective lectures will be published before fall, 1964, or sent by the Institute on request. This announcement is made in order to indicate the timetable in advance. Advance booking is desirable.

Participants at the all-day symposia on refuse-disposal techniques will contribute DM 10 for expenses.

BOOK REVIEW

V. S. A., Verband Schweizerischer Abwasserfachleute:"Wegleitung für die Beseitigung von Industrieabfällen (Guide for the Disposal of Industrial Waste), 1964 edition, paper back (Verband Schweiz. Abwasserfachleute, Richtlinienverlag, Postfach Aarau)

This stimulating booklet, without claiming to be more than a contribution to the general discussion, advances suggestions for disposal of industrial waste. In its first part terminology is clarified and fundamentals of restoration means mentioned. At the same time, the waste is classified according to the various possibilities of disposal, and the preliminary studies and work required for the solution of industrial waste problems are indicated. In the second part, technical directives are given for processing methods, the latter coinciding with the classification in the first part. Supplements complete this work.

This very welcome booklet represents the first part of a series of publications undertaken by the U.S.A., that will deal in detail with each problem. Although much has been written on the problems of household and urban refuse disposal, directives relating to industrial waste disposal are very limited. This pioneer work gives for the first time a comprehensive picture of the industries from which waste originates, and indicates the types of waste. At the same time, it offers numerous suggestions concerning restoration in specific cases, as well as the approach to the problem as a whole.

Correctly interpreted and used, this work will greatly contribute to maintaining cleanliness on the land, in the water and air; therefore, its widest distribution is most desirable.

A. v. H.

LITERATURE RECEIVED BY THE SECRETARIAT

Albinus, G. Müllgrossbehälter (Capacious Ash Cans). – Der Städtetag, Issue 4. 1964.

American Public Works Association. National Conference on Solid Waste Research. – Research Foundation, 1313 East 60th Street, Chicago 37. Proceedings, December 1963. 1963.

Andres, O. Absatz und Anwendung von Müllkompost in den Niederlanden (Disposal and Utilization of Refuse Compost in the Netherlands). – Mitteilungen der Deutschen Landwirtschafts-Gesellschaft, Issue 17. 1964.

Andres, O. Zur Wirtschaftlichkeit von Kompostierung und Verbrennung (Economic Aspects of Composting and Incineration). – Deutscher Kommunalverlag, Düsseldorf. Kommunalwirtschaft, Issue 4. 1964.

Andres, W. and B. Frechen. Stadtreinigung Duisburg (Town Cleaning in Duisburg). – Der Städtetag, Issue 6. 1964.

Block, H. and A. Duhme. Müllverbrennung nach dem System Völund (The Völund System in Refuse Incineration). – Aufbereitungstechnik, Wiesbaden, Issue 3. 1964.

Clark, J. W. Composting Domestic Refuse in a Home Unit. – Compost Science, Vol. 4. 1964.

Eberhardt, H. and H. Weiand. Ein neues Verfahren zur Verbrennung von Abwasserschlamm (A New Procedure of Sewage-Sludge Incineration). – Deutscher Kommunal-Verlag, Düsseldorf, Kommunalwirtschaft, Issue 4. 1963.

Erhart, H. Volkswirtschaftliche Betrachtungen zur Müllbeseitigung (Refuse Disposal from the Aspect of National Economy). – Städtehygiene, Issue 4. 1964.

Ferber, M. Durchführung von Mülluntersuchungen mit einer mobilen Analysenstation (Refuse Analyses with a Mobile Laboratory). – Der Städtetag, Issue 6. 1964.

Ferber, Kolkenbrock and Neukirchen. Müll-Anfall, Abfuhr und Beseitigung in Zahlen. Gutachten, erstattet für das Bundesministerium für Gesundheitswesen über die Ergebnisse der Müllstatistik 1961 (Statistical Data on Refuse Accumulation. Transportation and Disposal. A Report to the Federal Ministry of Health for the Year 1961). – Kommissionsverlag R. Oldenbourg, München. 1964.

Fontalirand, P. L'Exploitation de la décharge des ordures d'Angoulême. – Techniques et Sciences Municipales, 59th year of publ., No. 3. 1964.

Franz, W. Eine neue Müllverwertungsanlage in St. Georgen, Schwarzwald (A New Refuse-Reclamation Plant in St. Georgen, Schwarzwald). – Aufbereitungstechnik, Wiesbaden, Issue 3. 1964.

Furlow, H. G. and H. A. Zollinger. Westinghouse Enters Composting Field. – Compost Science, Vol. 4, No. 4. 1964.

Gerhart, R. and H. Ermer. Modelluntersuchung der optimalen Auslegung von Müllverbrennungsanlagen für kleine und mittelgrosse Städte am Beispiel der Müllverbrennungsanlage Neustadt in Holstein (Model Test for Best Layout of Refuse Incineration Plants in Small and Medium-Sized Towns on the Pattern of the Neustadt Plant Design in Holstein). – Aufbereitungstechnik, Wiesbaden, Issue 3. 1964.

Gioria, E. Müllsammlung und Strassenreinigung (Refuse Collection and Street Cleaning). – Der Städtetag, Issue 4. 1964.

Hart, S. A. Sanitary Engineering in Agriculture. – Compost Science, Vol. 4, No. 4. 1964.

Jäger, B. Sammlung und Aufbereitung von Sperrmüll (Collection and Treatment of Bulky Waste). — Aufbereitungstechnik, Wiesbaden, Issue 3. 1964.

Joachim, H. Die Müllverbrennungsanlage der Stadt Gluckstadt in Holstein (Refuse Incinerator in the Town Gluckstadt in Holstein). — Aufbereitungstechnik, Wiesbaden, Issue 3. 1964.

Kampschulte, J. Stand der Müllverbrennung in Hamburg (Situation of Refuse Incineration in Hamburg). — Städtehygiene, Issue 4. 1964.

Karnovsky, E. Beseitigung von Oel, Oelschlamm und Oelrückständen (Disposal of Oil, Oil Sludge, and Oil Residues). — Der Städtetag, Issue 5. 1964.

Kaupert, W. Zur gegenwärtigen Praxis der Müll-Ablagerung (On the Present Practice of Refuse Dumping). — Städtehygiene, Issue 4. 1964.

Kaupert, W. Müllverbrennung in grossen and kleinen Städten (Refuse Incineration in Large and Small Towns). — Städtehygiene, Issue 5. 1964.

Knabe, W. Bericht über neue Forschungsergebnisse auf dem Gebiet der Kippenrekultivierung in der Niederlausitz (Report on Recent Research in the Field of Dump Reclamation in Niederlausitz). — Hilfe durch Grün, Verlag Stichnote, Darmstadt, Issue 9. 1960.

Knabe, W. Forstliche Rekultivierung von Industrieland (Afforestation of Industrial Areas). — Forstplanzen-Forstsamen, Zentralblatt für Forstpflanzen und Forstkulturen, Wirtschafts- und Forstverlag Strassenhaus Euting K. G. 1962.

Knoll, K. -U. and D. Strauch. Ein neuer Weg zur Aufbereitung und Verwertung von Siedlungsabfällen. Die hygienische Wirksamkeit des "Brikollare-Verfahrens" (A New Method for Treatment and Reclamation of Settlement Refuse. The Hygienic Efficiency of the "Brikollare Process"). — Der Städtetag, Issue 5. 1964.

Krige, P. R. The Utilization of Municipal Wastes. Report on the Processing of Urban Wastes in a Mechanized Composting Plant. — CSIR Research Report No. 211, Pretoria, South Africa. 1964.

Lancoud, F. Die Stadtreinigung in Genf (Town Cleaning in Geneva). — Der Städtetag, Issue 4. 1964.

Mahlke, H. Abgasschäden durch Verbrennungsgase aus Kraftfahrzeugmotoren (Injurious Exhaust Gases of Motorized Vehicles). — Der Städtetag, Issue 4. 1964.

Meyer, G. Aufbau und Wirkundsweise einer MS-Brennkegelanlage mit Müllzerkleinerung (Construction and Operation of an MS-Pyrometric-Cone Plant with Refuse Comminution). — Aufbereitungstechnik, Wiesbaden, Issue 3. 1964.

Naik, B. N. Putting Leather Waste to Use. — Compost Science, Vol. 4, No. 4. 1964.

Oates, J. T. How Municipalities Can Use Wood Chips. — Compost Science, Vol. 4, No. 4. 1964.

Parrakova, E., R. Entnerova, and R. Lamprecht. The Location of Refuse Bins in Block Buildings from the Hygienic Aspect. — Československá Hygiena, Vol. 7, No. 9. 1962.

Reppert v., R.L. An Economical Method for Dewatering Sewage Sludge. — Compost Science, Vol. 4, No. 4. 1964.

Rohde, G. Bedeutung der natürlichen Chelatbildner für die biologische Verwitterung (The Importance of Natural Chelating Agents in Biological Decomposition). — Städtehygiene, Issue 4. 1964.

Schatz, A., V. Schatz, E. B. Schalscha, and J. J. Martin. Soil Organic Matter as a Natural Chelating Material, Part 1: The Chemistry of Chelation. – Compost Science, Vol. 4, No. 4. 1964.

Shatzel, L. R. Composting Methods at Kingston, Jamaica. –Compost Science, Vol. 4, No. 4. 1964.

Spohn, E. Abfallbeseitigung durch Kompostieren? (Refuse Disposal by Composting?). – Städtehygiene, Issue 4. 1964.

Stockli, A. Die Metazoic Fauna der Komposterde (The Metazoic Fauna of Compost Soil). –Schweizerische landwirtschaftliche Forschung, Issue 1, Benteli Verlag Bern-Bumpliz. 1964.

Tope, O. Sonderfahrzeugverkehr in der Strassenplanung (Special Vehicle Traffic in Street Planning). – Der Städtetag, Issue 4. 1964.

VSA, Verband Schweizerischer Abwasserfachleute. Wegleitung für die Beseitigung von Industrieabfällen (Instructions for the Disposal of Industrial Waste). – VSA-Richtlinien-Verlag, Postfach Aarau. 1964.

Wiebecke, F. Erfahrungen mit automatischen Waschanlagen (Experience with Automatic Washing Plants). – Der Städtetag, Issue 6. 1964.

Wienbeck, U. Erfahrungen mit dem Müllsack in Hamburg (Experience with Refuse Sacks in Hamburg). – Der Städtetag, Issue 5. 1964.

Wuhrmann, K. Probleme der Müllzerkleinerung (Problems of Refuse Comminution). – Aufbereitungstechnik, Wiesbaden, Issue 3. 1964.

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ORGANIZATION OF REFUSE DISPOSAL

By Dipl.- Ing. Dr. Franz Heigl, Graz

Refuse dumping grounds are a characteristic of all civilized settlements, if we infer by civilized settlements any region inhabited by man. Nevertheless, the problem of refuse dumping grounds as a factor in town planning was treated for the first time by Dr. Rechenberg in "Das Einmaleins der Siedlung," published in 1940. In his studies of communities not exceeding 20,000 inhabitants, the unit area required for 1,000 inhabitants is established at 242 m^2, and it is assumed that preparation of a dumping site is justified when the population reaches a minimum of 600 inhabitants. His suggestions of using the refuse for leveling troughs and filling in water holes clearly reflect the radical change that has since taken place in regard to concepts of hygiene.

The building questions of several decades ago have grown into real problems of town planning.

The material was first dumped near urban settlements, in abandoned stone quarries, sand and gravel pits, as also suggested by Rechenberg. Regrettably, this method is still practiced in small communities. However, at the beginning of this century larger towns were compelled to transport their refuse by railway to distant sites in order to protect the inhabitants from dust, disagreeable odors, pests and pathogenic agents.

Attempts were made to eliminate these inconveniences by covering the dumps with earth and treating them with slaked lime and similar means.

In Frankfurt a/M the yearly refuse amounts to 800,000 m^3 and, since about 1920, has been dumped in the so-called town forest. The dumping ground has now reached the proportions of a hill, 50 m high, and is spreading over an area of approximately 15 ha. At that rate the dumping area is estimated to expand yearly by one hectare. It is therefore intended to incinerate the incoming wastes in future and, in any case, to prevent the formation of such refuse hills, since no use can be made of their surroundings, especially in rainy weather.

Their location in the green belt is undesirable because the latter will lose its recreational value, and fire danger, especially to conifers, will arise.

It is hoped, however, that the Frankfurt refuse hill will again be afforested when covered with an adequate layer of compost.

What means have the town and regional planning authorities at their disposal for averting the negative effects of refuse dumps?

Air pollution and contamination of groundwater are the main concern.

The degree of pollution from refuse dumps to which groundwater is exposed is clearly illustrated by the data reported by Dr. Flögel, Linz. According to these, the speed of the subterranean river flowing parallel to the Tran River, and several kilometers wide, amounts to 1.2 m^3 per second, whereas the yearly precipitation per hectare reaches 6,000 m^3, or an average of 0.2 liter per second. Notwithstanding the theoretical peak of 2 l per second per hectare (most of which is drained into surface waters), the amount of infiltration is quite significant, all

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the more so, since a few hundredths of a milligram of leached matter suffice to make the water undrinkable.

Evidently, the danger is considerably diminished when the rainwaters washing the refuse dumps flow into surface streams. There, they are highly diluted and pollution is readily detected, whereas in groundwater detection of pollution is greatly delayed and takes place far from the source.

The complex problem we then face involves the relatively slight proportion of infiltration from refuse dumps and the irreparable damage it inflicts.

Even if the dump is removed, restoration of the site to the initial conditions is a lengthy process.

In general, the refuse dumps could be drained and the sites selected so as to exclude regions of alluvial and deluvial gravel. However, if local conditions impose the use of such areas, refuse disposal should be preceded by thorough examination of the terrain.

The danger of polluting the groundwater may be averted by insulating the bottom with an impermeable layer. The basin thus formed should be dewatered and adequately drained after rainfall; these operations are greatly facilitated by a sloping base. The possible disadvantages of canalizing these waters into the main drainage channel should be examined in each individual case. In certain cases the drainage water should be filtered or chemically treated. Care should be taken that no water-supply sources are situated between the dumping site and the course of the river, and no wells sunk on the distant side of the river, if these sources and wells are fed by shore-filtered groundwater flowing in from under the dumping place. Installation of new wells and operation of old ones within the radius of infiltration from the dumping place is to be avoided. The required distance between the well and dumping site depends upon the findings of geological investigations.

Gravel pits and bomb craters are not suitable for dumping because they are devoid of a natural weathering layer and cannot be drained.

More accurate data concerning the second aspect of the damaging effects of refuse and slagheaps, i.e. the effects on the atmosphere, have been revealed only recently. The sad aftermath of the war, the extensive ruins and bomb craters have accelerated studies on the nuisance of dust formation: chalk and concrete particles, sand and brick dust whirling round many years after their formation, deposited in regions with little air movement, or given favorable conditions, carried over distances of many kilometers.

The same is true for dumping areas.

From the hygenic point of view, the inconveniences of dust ($\geq 5 \times 10^{-5}$) and fine particles ($5 \times 10^{-5} - 1 \times 10^{-7}$) consist indirectly in their contribution to haze and smog formation, and hence obstruction of solar radiation, and directly in the irritation of the respiratory tracts and the infection of the latter with pathogenic agents carried by the dust. While coarse particles are more annoying, the fine particles are, by far, more damaging.

The effect of green belts and shelterbelts around dumping sites on the reduction of dust has been investigated from different aspects and by different methods of estimation. In addition, the results obtained proved to be correlated with the prevailing topographical and meteorological conditions.

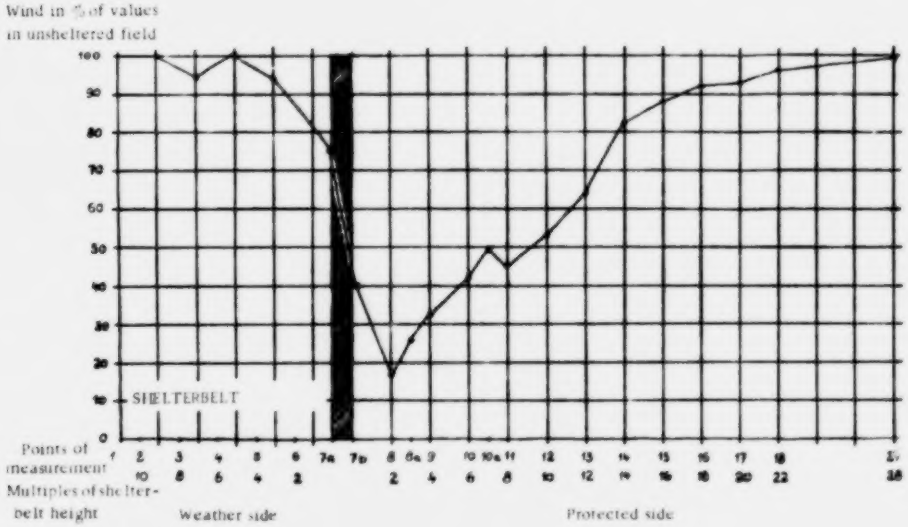
Moreover, the effect of verdures on the dust-content of air and on sedimentation also depends upon the size of dust particles, their origin and direction, as well as upon the location and structure of the plantation. In general, dense plantations and forests should arrest, in certain conditions, the waves of fine particles and germs, while most of the coarser dust is trapped and reduced to approximately 20% (from 2,630 to 590 dust particles/100 cm^3 air).

As established by dust determination in dense plantations, values tend to be higher on the protected side of the plantation, owing to sedimentation which is caused by the drop in wind velocity after jumping the obstacle. In sparse plantations the highest dust sedimentation was found immediately behind them. The dust-content of the air was reduced to 50%.

These findings have been repeatedly recorded. Thus, Kranz showed that winds blowing at higher velocities over and through narrow shelter belts first reduce sedimentation on the sheltered side, and only later lead to maximum sedimentation.

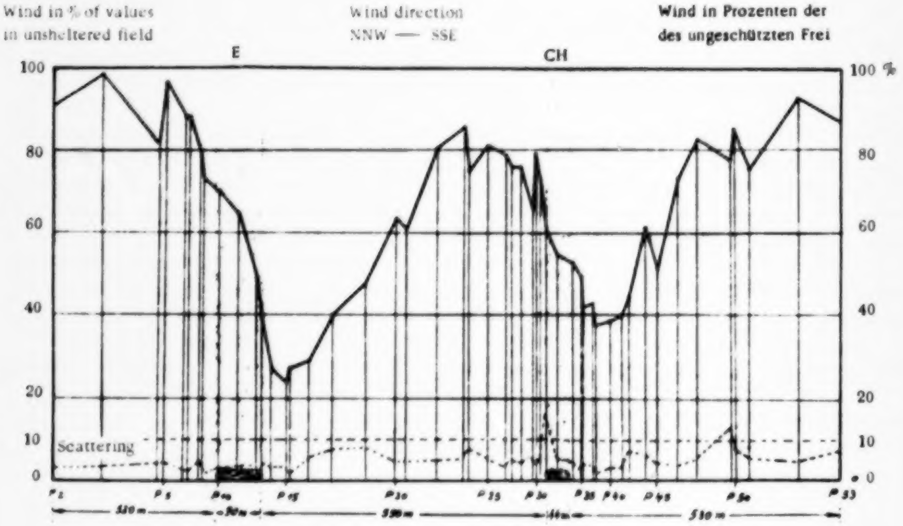
This is explained by the fact that the particles are carried over the plantations by the higher velocity of the winds and owing to the reduced static pressure at the border area of the still-air zone. After the plantation has been thoroughly blown through, and wind-field and velocity return to normal, the carrying power of the current diminishes. The particles settle and sedimentation again reaches the maximum. Measurements at average wind velocities at the points of dust determination confirmed these correlations. The speed of the current is reduced in the shelterbelt and around it. The initial velocity is regained far on the protected side and then higher dust values are again recorded.

These correlations are best illustrated by diagrams.

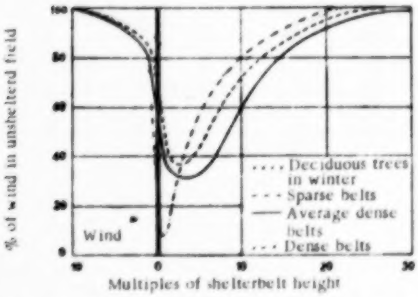


A Shelterbelts as windbreaks

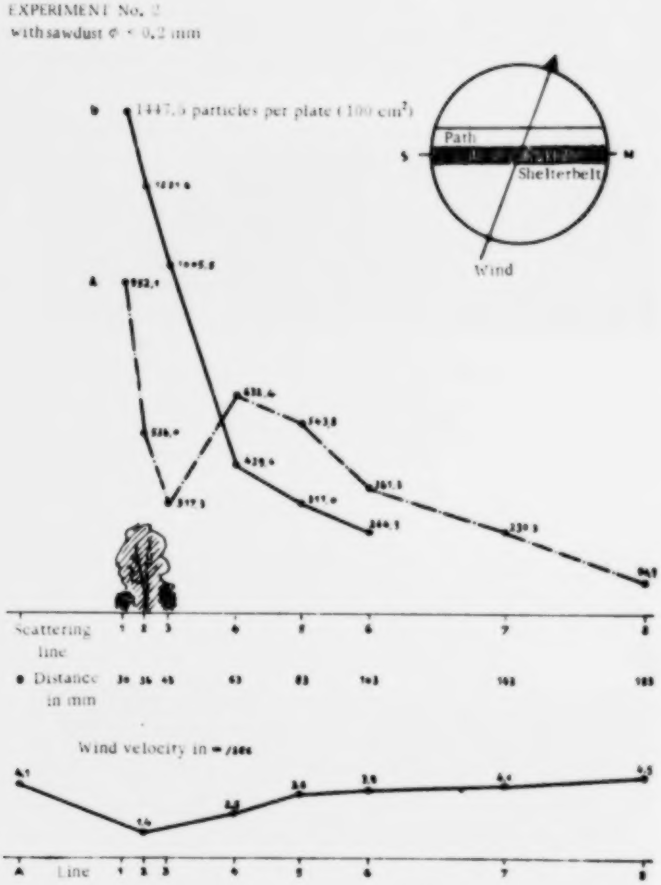
(From: K. Ilner and K. Gandert. Windschutzhecken, Deutscher Bauernverlag, p. 25, Berlin W 8., 1956.)



B. Wind conditions in areas of successive shelterbelts, acc. to Nägeli.
(From: K. Illner and K. Gandert: Windschutzhecken, Deutscher Bauernverlag, p. 35, Berlin W 8, 1956.)



C. Protective effect of different shelterbelts, acc. to Nägeli. (From: K. Illner and K. Gandert, Windschutzhecken, Deutscher Bauernverlag, p. 27, Berlin W 8., 1956.)



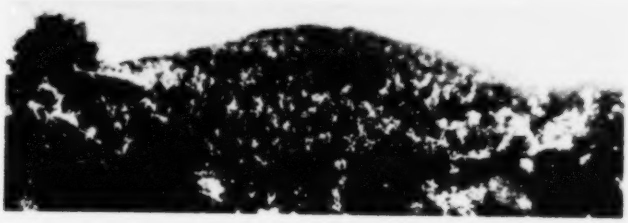
D. Sedimentation of particles scattered on the weather side
a) in and behind a shelterbelt
b) in unsheltered field

From: K. Illner and K. Gandert, Windschutzhecken, Deutscher Bauernverlag, p. 50, Berlin W 8., 1956.

Taking into account these difficulties, it seems that dumping sites are best located not too far away from flowing water (infiltration water, air humidity), and leeward in relation to the town. Tree belts should be left between the refuse heaps to allow subsequent afforestation of the dumping area. Thus, the harmony of the landscape can be reestablished, noxious odors, dust and other inconveniences reduced, and pollution of infiltration water kept low.

From the regional and town-planning point of view the sites selected for refuse disposal and reclamation plants should lie between the industrial area and the green belts, as far away as possible from water-protection and residential zones.

Restoration of the dumping grounds is imposed by economic, cultural and biological considerations. For optimal results, dumping and planting should go hand in hand. Detailed advance planning is now the rule for larger dumping areas.



E. A plantation of red alder, white alder and red oak in the second vegetation period. If the refuse slopes are not too steep and erosion hazards not too pronounced these trees can be planted without preparatory work.
From: Unser Wald, Zeitschrift der Schutzgemeinschaft Deutscher Wald EV, No. 5. p. 134, Frankfurt a/Main, 1967. (Forstassessor H. J. Berthold) Die grünen Hügel des Reviers.

F. A closed forest of deciduous trees now covers the ruins of a mining site in Oer-Erkenschwick.
From: Waldschutz und Landschaftspflege im Ruhrgebiet, published by Siedlungsverband Ruhrkohlenbezirk, p. 21, Essen, 1963.

Although restoration of refuse heaps is determined by the composition of the refuse, extent of digestion, pH-values, and other factors, its success will be assured if the surface of the dumping site, and especially its slope, are suitable for planting. Steep slopes are too arid for vegetation, and erosion damages may endanger the refuse heap and the adjoining plantations. The extent of such washouts is illustrated by Figure G (Dumps in the Ruhr Region).

G. Urban landscape in North Essen
From: Waldschutz und Landschaftspflege im Ruhrgebiet, published by Siedlungsverband Ruhrkohlenbezirk, p. 6, Essen, 1959.

It should be remembered that plantations on the southern and western slopes are exposed to prolonged sunshine, strong winds and rain storms.

The following measures are recommended for successful restoration

1. The top soil of the dumping site should be removed and stored until needed for covering the refuse heap. If material injurious to plants, such as boron or alkalis, predominates, the refuse should be first covered with earth, sand, household or building refuse of finer consistency before the final layer of humus is placed on the heap. The covering layer should be 75 - 100 cm thick. In this connection I refer to the restoration of the coal-mining regions in Germany.

2. High steep slopes and pointed coniform heaps should be avoided because drying up, especially in the upper part, and the washouts along the unbroken slope make maintenance of plantations very difficult. Most advantageous are table-shaped heaps, but the actual terraces should not be too high. A prototype of such dumping heaps can be seen at the mine Prinz v. Preussen in Bochum.

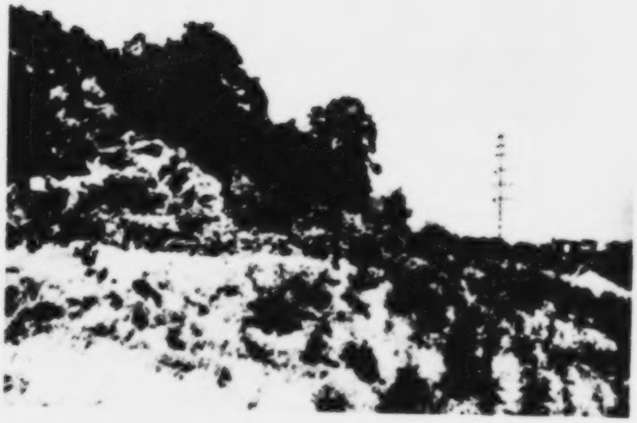
Experience has shown that the desirable height of terraces is 8 to 10 m, allowing, in certain circumstances, up to 15 m for the lowest terrace. The slope is generally that of the natural tipping angle of the material. A gradient of 1 : 2, or 26.5° is tolerable.

The width of the terrace is generally 4 m, but, as a rule, coarse material requires larger steps.

The inherent danger of erosion is diminished when the terrace slopes towards the point of intersection of the cone, or is supported by a low outer wall. The plateau on top should be similarly built. However, if the dumps are relatively low, the foot of the cone can be flattened at the lowest two or three meters to a proportion of 1 : 3. This is particularly desirable for the harmonious integration of these artificial formations into the general landscape.

H. Dumps are especially exposed to erosion. Such washouts and slips imperil the cultivated or inhabited surrounding areas.
From: Unser Wald, Zeitschrift der Schutzgemeinschaft Deutscher Wald EV, No. 5, p. 133, Frankfurt a/Main, 1957.
(Forstassessor H. J. Berthold) Die grunen Hugel des Reviers.

I. Dumps of the mine Prinz von Preussen in Bochum.
Terraces are prepared for future plantations.
From: Unser Wald, Zeitschrift der Schutzgemeinschaft Deutscher Wald EV, No. 5, p. 135, Frankfurt a/Main, 1957. (Forstassessor H. J. Berthold): Die grunen Hugel des Reviers.



J. Planted dumps of the collieries in the Bottrop area.
From: Waldschutz and Landschaftspflege im Ruhrgebiet, published by Siedlungsverband Ruhrkohlenbezirk, p. 22. Essen, 1969.

Directly upon acquisition of a dumping site the respective community should start planting wood strips, at least 20 m wide, so as to cover the entire area with a network of timber. The distance between the strips should be determined according to the average velocity of the winds so that at normal velocities the dust will not be carried over the tree border. Should the wind velocity occasionally exceed the presumed critical point, the plantations surrounding the reserve sectors will act as additional filters.

Extensive plans have been elaborated in Munich for exploiting all possibilities of converting refuse into productive land and at the same time gaining a desirable hilly structure for a resort site. Dr. Leo Freiherr von Ow has published a study under the title "Erholungsgelände im Norden Münchens", suggesting the conversion of the Isar meadows and surroundings into a wide recreational area for Munich. He recommends the planning of dumping hills that will ultimately confer to the region the natural aspect of a hilly landscape. According to his suggestion, the town refuse should be used as the initial material.

The overburden from new gravel pits and humus removed from the dumping sites will eventually serve to cover the newly gained countryside.

Precautions should be taken not to pollute the lake and bathing waters. The dumps will be situated in the north, i.e., down the river. They should be high enough to provide for winter sports.

Realization of such a project requires accurate planning of plantation.

In the first stage a shrubbery-weed society is to be furthered since such plants are best adapted to the severe conditions on the dumps. This society is characterized as the first continental settlement on warm and dry sites; it requires a large amount of nitrogen compounds, is found on river banks and forest outskirts, but settles also on freshly littered ground rich in nutritive matter. It is therefore most suitable for plantation on dumping grounds. The society consists mainly of three plants

Clematis vitalba – traveler's joy; Rubus idaeus – raspberry; Sambucus nigra.

Plantation proceeds according to the following schedule

1. Examination of the site.
2. Plantation of shrubs and at about the same time, the fast growing pioneer forest trees.
3. Plantation of main forest trees under the protection of the pioneer stand.
4. Maintenance of mixed forest.

The species of pioneer trees to be planted should be decided upon as soon as the type and extent of the shrubbery are known, since the fast growing trees represent the main potential growth for the following 10–15 years and continue in later years to play an important role in production. Local conditions limit the choice of trees and the area to be planted.

The pioneer plants for restoration of refuse heaps and dumps are: maple, birch, field birch, weeping birch, cornel-berry, hawthorn, broom, ash, privet, milk-wetch, etc.

Finally the principal tree species to succeed the pioneer species have to be selected.

Studies are in progress in Germany on selection of species resistant to alkaline soils. Experimental plantations on light-ash dumps have been carried out. Results have not yet been published.

Thus, refuse disposal and reclamation may transform a negative factor into a positive one for human society, provided the problem is properly treated.

Bibliography

Bernatzky, A. Von der mittelalterlichen Stadtbefestigung zu den Waldgrunflachen von heute (From the Medieval Town Fortification to Today's Green Forest Areas). – Bernhard Patzer-Verlag, Berlin–Hannover. 1960.

Heger, A. Die Begründung von Mischwaldern auf Grosskahlflächen unter besonderer Berucksichtigung des Vorwaldgedankens (The Planting of Mixed Forests on Large Clearings with Special Regard to the Idea of Preliminary Forests). – Neumann Verlag, Radebeul and Berlin. 1952.

Hennebo, D. Staubfilterung durch Grunanlagen (Dust Filtration by Means of Parks). – VEB Verlag, Technik, Berlin, Wissenschaftliche Berichte, Series 11, Bauwesen, Issue 19. 1955.

Hornsmann, E. Allen hilft der Wald (seine Wohlfahrtswirkungen) (The Forest Helps Everybody (Its Beneficial Effects)). – BLV Verlagsgesellschaft München – Bonn – Wien. 1958.

Illner, K. and K. Gandert. Windschutzhecken (Windbreak Hedges). – Deutscher Bauernverlag, Berlin W 8. 1956.

Kratzer, A. P. Das Stadtklima (The Town Climate). – Friedr. Vieweg und Sohn, Braunschweig. 1956.

Kumpf, Maas and Straub. Mull- und Abfallbeseitigung (Waste and Garbage Disposal). – Erich Schmidt Verlag, Berlin. 1964.

Mading, E. Landespflege (Landscaping). – Deutsche Landbuchhandlung, Berlin. 1942.

Ow, L. Freiherr von. Erholungsgelände im Norden Münchens (Recreation Areas in the North of Munich). – C.H. Beck, München, no year of publ.

Press, H. Taschenbuch der Wasserwirtschaft (Pocket-Book of Water Economy). – Verlag Wasser und Boden Axel Lindorf and Co. Hamburg-Blanchenese. 1960.

Rechenberg, F. Das Einmaleins der Siedlung, Richtzahlen für das Siedlungswesen (The ABC of Settlement, Guiding Figures for Settlement Management). – Verlag Julius Springer, Berlin. 1940.

Rindt, O. Gehölzpflanzungen am fliessenden Wasser, unter Berücksichtigung des Uferschutzes (Tree Plantations along Flowing Water, with Regard to Bank Protection). – Verlag Technik, Berlin. 1952.

Ruppert, K. Der Stadtwald als Wirtschafts- und Erholungswald (The Town Forest as a Factor of Urban Economy and Recreation). – BLV Verlagsgesellschaft, München–Bonn–Wien. 1960.

Without author. Sammlung, Aufbereitung und Verwertung von Siedlungsabfällen (Collection, Processing and Utilization of Municipal Waste). – Pocket-Book, published by Arbeitsgemeinschaft für kommunale Abfallwirtschaft (AkA) Baden-Baden. 1960.

Wiepking-Jürgensmann, H. F. Die Landschaftsfibel (The ABC of the Countryside). – Deutsche Landbuchhandlung, Berlin SW 11. 1942.

Unser Wald. Zeitschrift der Schutzgemeinschaft Deutscher Wald, EV Frankfurt a/M 5, 1957 (Journal of the Schutzgemeinschaft Deutscher Wald (Association for the Protection of German Forests), EV Frankfurt a/M 5, 1957). – Published by Siedlungsverband Ruhrkohlenbezirk, Essen. 1959.

EFFECT OF LIQUID MANURE WITH OR WITHOUT THE ADDITION OF SEWAGE SLUDGE ON THE CONDITION OF PLANTS

By P. Schenker, Eidg. agrikultur-chemische Versuchsanstalt, Liebefeld-Bern

Experimental manuring with liquid manure alone and also supplemented with sewage sludge was carried out over a period of five years (1955 – 1959) in cooperation with the dairy farms experimental stations, in an old artificial meadow. The experiment aimed at clarifying whether the addition of sewage sludge

1. has a detrimental effect on the milk, from the bacteriological aspect,
2. modifies the meadow vegetation.

The effect on the milk was examined at the Liebefeld Federal Experimental Station. No untoward changes in the content of microorganisms could be established. *

The results obtained for the second question are reported hereunder. As the experimental area was too small to provide uniform yields (four microplots of 1 m^2 each) the determinations have only a comparative value.

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* According to the report of the Special Commission for Milk-Products Technology of 16. 12 1959.

Experimental

At the Munsingen Institute, two adjacent old artificial meadows flanked by apple trees, were chosen for the experiment in the spring of 1955. One (L) was manured only with liquid manure, the other (LS) with liquid manure plus sludge. The plots were manured before the growth period and after each cutting (Figure 1). The sludge was obtained from the sewage sludge digesting tank of the Langenthal sewage-disposal plant and mixed before use with the liquid manure in a proportion of 1 : 3. The liquid manure and sludge were supplied by the plant in the usual uniform amounts without any special check on our side.

The average contents of 11 sludge samples, examined by EAWAG in the years 1955 - 1957, and of 11 samples analyzed at Liebefeld from 1956 to 1959, are summarized in the following table. For comparison, the data of two sludge-sample analyses are tabulated, as well as those of the mixture L + S (2:1) of 1 July 1957; also, the average content of a 4-fold diluted liquid manure rich in fecal matter without the addition of sludge (analyzed at Liebefeld).

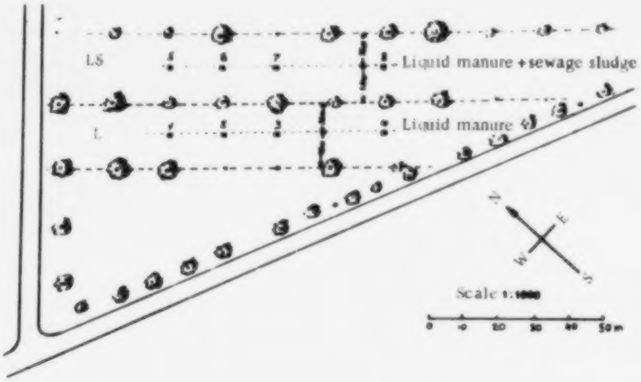

Figure 1. Sludge experiment in Münsingen 1955–1959
(Farm of Kantonale Heil- und Pflegeanstalt)

☐ = 1 m² experimental area
(marked on the ground)

As evident from Table 1, S in contrast to L, is poor in alkali though rich in phosphoric acid and, therefore, an excellent additive for the balance of nutrients.

According to data supplied by Mr. Lehmann, administrator of the Münsingen Institute, the two artificial meadows were of the same origin, displaying similar vegetation. Presumably, they were not quite of the same age; subsequent soil analysis revealed certain differences. Unfortunately, those were the only comparable meadows, each of which could supply 4 cows with sufficient food throughout the summer.

TABLE I. Analyses of sludge, liquid manure and mixtures of both

	H_2O	Fz	Ash	Organic matter (Org. C)	N	P_2O_5	K_2O
	g/l	g/l	g/l	g/l	g/l	g/l	g/l
Sludge L'thal 1955 - 1957, mean content of 11 samples (EAWAG)	861,0	139,0	96,9	42,1 (22,1)	2.88	1.76	0,76
Sludge L'thal 1956 - 1959, mean content of 11 samples (Liebefeld)	832,5	167,5	121,9	45,6	3,12	2.66	0,35
1.7.1957(Liebefeld)							
Sludge I	799,0	201,0	147,0	54,0	3,52	1.49	0,4
Sludge II	808,0	192,0	138,0	54,3	3,35	1,46	0,4
L + S	954,9	45,1	28,0	17,1	1,63	0,32	2,8
L, rich in fecal matter, 4 × diluted, mean content (Liebefeld)	945	55,0	20,0	35,0	1,4	0,5	3,0

For the sake of uniform sampling of the vegetation, four separate sampling plots of 1 m² were marked along the median line of each meadow with the aid of wooden pegs buried in the ground and provided with removable, red-painted iron rods. According to plan, the green and dry weight of the forage on these plots should have been determined at each cutting of the meadows, and their botanical composition determined or, at least, estimated once a year. Unfortunately, several cuttings were performed before the directives were properly applied. Consequently, our report is limited to those cuttings in which grasses, white clover and weeds (dandelion) were separated, and their air-dry weight determined; they comprise, however, the 1958 harvests of the four cuttings carried out according to plan.

Botanical composition and yields

At the beginning of the experiment both meadows displayed a well balanced vegetation rich in grasses profusely intergrown with white clover (Trifolium repens) and dandelion (Taraxacum officinale). Nidi of Rununculus repens (buttercups), Glechoma hederaceum (ground ivy) and Bellis perennis (daisies) were encountered in both. Among grasses, Lolium italicum (Italian ryegrass) predominated over Poa trivialis (roughstalk bluegrass) and Dactylis glomerata (orchard grass). Red clover was almost entirely absent, while sporadic stands of alfalfa (Medicago sativa) occurred in plot L (without sludge).

Data of the last few years (see also Figure 2):

1955. The botanical analysis of the first cutting (5 May) revealed the following composition for each 4 m²:

TABLE 2

Samples of 5.5.1955 Plots	Grasses		White clover		Dandelion		Total (each 4 m²) g air-dry
	g	%	g	%	g	%	
L* 1 - 4 1 m² each	1,118	67.4	282	17.0	258	15.6	1,658
LS 5 - 8 1 m² each	1,318	76.7	206	11.5	211	11.8	1,788

L = liquid manure
LS = liquid manure + sludge (2 : 1)

The L-plot displayed slightly more clover and weeds, and less grasses than plot LS.

1956. The L-plot was cut on 21 May, whereas the LS-plot had been cut earlier because of its allegedly earlier readiness for cutting. Subsequently, the cutting dates varied until the best cutting, which was carried out simultaneously in both plots, on 22 August. Thus, plot L yielded three cuttings whereas plot LS yielded four. The plant composition was established in the fourth cutting.

TABLE 3

Samples of 22.8.1956 Plots	Grasses		White clover		Dandelion		Total (each 4 m²) g air-dry
	g	%	g	%	g	%	
L 1 - 4	548	51.3	431	40.3	90	8.4	1,069
LS 5 - 8	536	51.0	477	45.3	38	3.6	1,051

1957. Both meadows were consistently cut according to plan, at the same time. In the first cutting a significant predominance of dandelion over white clover was found in L-plot. The same was found in the second cutting.

TABLE 4

Samples of 26.4.1957 (1st cutting) Plots	Grasses		White clover		Dandelion		Total (each 4 m²) g air-dry
	g	%	g	%	g	%	
L 1 - 4	610	60.7	170	16.9	225	22.4	1,005
LS 5 - 8	564	61.3	310	33.8	43	4.7	917
Samples of 13.6.1957 (2nd cutting)							
L 1 - 4	625	55.5	336	29.9	161	14.6	1,125
LS 5 - 8	700	52.4	395	44.5	41	3.1	1,336

1958. Of the four cuttings removed according to plan botanical determinations were made only of the second. In the L-plot, manured solely with liquid manure, the proportion of dandelion was significantly higher in all samples, and that of grasses correspondingly lower than in the LS-plot.

TABLE 5

Samples of 11.6.1958 Plots	Grasses g	 %	White clover g	 %	Dandelion g	 %	Total (each 4 m²) g air-dry
L 1 - 4	642	14.5	396	27.5	404	28.0	1,442
LS 5 - 8	1,398	72.9	401	20.0	119	6.2	1,918

In the following table the total yields of all four cuttings are summarized.

TABLE 6

4 cuttings 1958 Plots	1st 5.5 g	2nd 11.6 g	3rd 15.7 g	4th 19.8 g	Total of 4 cuttings from each 4 m² g air-dry	
L 1 - 4	1,135	1,442	1,054	1,055	4,686	117 q/ha
LS 5 - 8	885	1,918	1,240	1,359	5,402	135 q/ha

Both the total and individual yields of three cuttings were higher in LS-plot than in L-plot. The higher yield of the first cutting of L, which exceeded that of LS also in 1957, may possibly be explained by the larger proportion of dandelion which, in relatively dry springs, produces more foliage than the grasses.

1959. Several samples were cut by mistake before the scheduled time. The botanical composition was estimated in the field and showed again the proportion of dandelion 10 - 20% in L as against 5 — 10% in LS. The proportion of white clover in both plots reached approximately 30 - 35%, and grasses - 50% and 60%, respectively (see diagram, Figure 2).

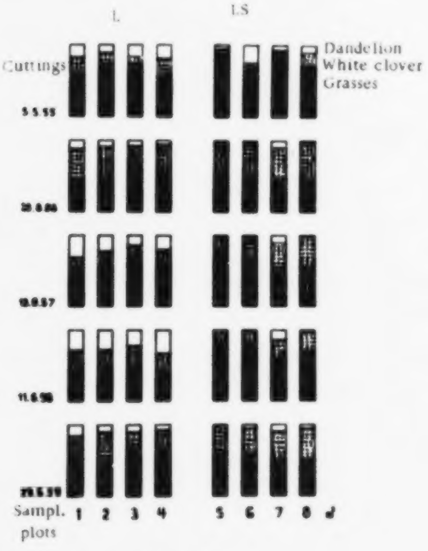

Figure 2. Sludge experiment, Munsingen. Plant components in %

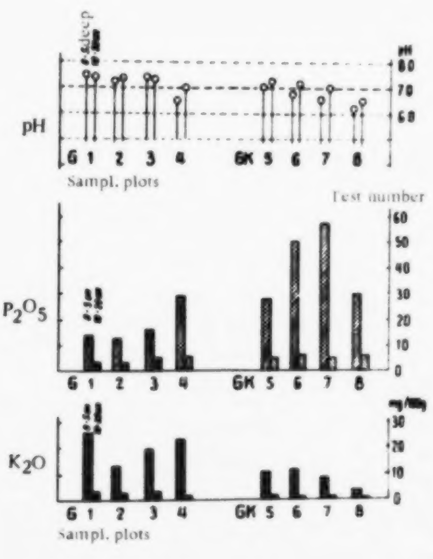

Figure 3. Sludge experiment, Munsingen. Soil analyses, 1959

Soil analysis

Soil analysis was undertaken only at the end of the experiment (1959). The upper soil layer (0 – 5 cm deep) showed pH values above 7 in three samples of the L-microplot. In the LS-plot, only one sample had pH = 7.1; in the other three samples pH-values varied between 6.2 and 6.8. At 10 – 20 cm depths, with the exception of sample 8, pH-values varied from 7.0 to 7.5, and carbonate concentrations from traces to 12.9%.

In the top layer (0 – 5 cm) of L-plot, alkali content was considerably higher (13.0 – 26.6 mg % K_2O) than in LS-plot (4.2 – 11.6 mg % K_2O). Conversely, the P_2O_5 values determined in the L-plot ranged from 13.7 – 29.0, whereas in the LS-plot they ranged from 28 – 58.

Summary

The effect of manuring at each cutting with liquid manure alone, or supplemented with sludge, on the milk used for cheese production was studied on experimental plots, the plant composition of which was examined in the course of 5 years. No undesirable effect of the sludge on the plant composition could be established. The proportion of white clover remained high, whereas the proportion of dandelion showed a transitory significant increase. Comparative yield determinations were not intended.

EFFECT OF A SINGLE HEATING ON FURTHER DIGESTION OF THE COMPOST

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The basis of mineralization and humification processes in composts consists of organic matter, which should be regarded as both the initial substrate for humus production and the source of energy required by the microflora producing the humus. According to Millar, 60% of the initial organic matter is mineralized and 40% humified under favorable conditions. In our experience (Novák, 1958), even 55% of the initial organic matter may be converted into humus, in appropriate conditions.

The energetic changes arising in the course of digestion are reflected in the temperature of the compost, i.e., the temperature changes indicate the intensity of the process. Kaila maintains that a temperature rise to 65° C is an essential condition for humification in the first stage of digestion, when the organic matter breaks down into dark-colored compounds which are subsequently synthesized into humus at temperatures ranging from 30 to 50° C. Glathe correlated the considerable temperature rise in the first stage of digestion with the intense proliferation of thermophilic microflora, which in favorable conditions may raise the temperature of the compost to 50 - 58°C, within 48 hours. Imshenetskii points out that the biochemical activity at a certain temperature interval is increased according to Van't Hoff's law. The rate of biochemical activity and microbial proliferation is doubled or trebled at a 10° rise in temperature.

The course of all processes involved in digestion and the digestion products depend also upon the first stage of compost digestion, i.e., we can influence the entire process from the time of piling. The digestion conditions of compost prepared from urban refuse, the siftings of which provide the main raw material, are considerably better in summer than in winter.

The ground winter refuse is poorer in organic matter than the summer material, and the ratio of organic to nutritive matter, especially the C : N ratio, is also less favorable. In addition, the unfavorable temperatures of both raw material and atmosphere frequently reduce the microbial activity. In favorable conditions, the compost warms up in spring, either by direct solar irradiation or owing to the higher temperature of the environment. Only then can the compost warm up further, owing to the heat evolved by the breakdown processes of digestion.

Taking into account that large-scale production is worthwhile only under continuous operation of the installations of the composting plant, intensive digestion of the compost should be ensured also in winter. In the light of the prevailing conditions we consider that the unfavorable natural factor might be artificially corrected.

In the present report we endeavor to prove that our aims were actually achieved.

Method

The compost was heaped at the end of January, one week before the planned single warming-up, in the following proportions:

40 parts winter ground refuse
20 parts digested sewage sludge
20 parts turf
10 parts liquid refuse from piggeries (for pig fattening)
3 parts bone meal.

The compost heap was 3 m wide, 1.4 m high, and 4.5 long. Drainpipes were laid along the bottom of the heap at intervals of 7 – 8 mm (Figure 1). At a distance of 1.2 m from the edge of the compost heap steam was passed through these pipes for 13 hours at a pressure-free, moderate flow. A total of 8,000 to 10,000 kilocalories was introduced in the steamed site.

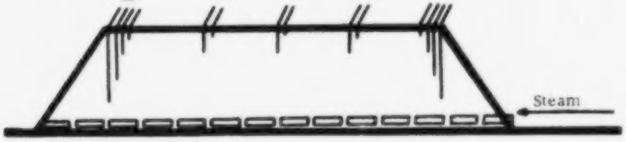


FIGURE 1. Diagram of compost heap
Heating pipes at bottom. A, B main sets, C, D, E, auxiliary sets of thermometers

The temperature changes, as primary indicators of microbial activity, were recorded with the aid of two main sets of thermometers (Figure 1). Set "A" was placed at the site of steam inlet and set "B" at the opposite end, at the same distance from the edge. Temperatures were measured by both sets of mercury thermometers at depths of 80, 65, 40, and 20 cm. Between the two main sets, auxiliary thermometer sets ("C," "D," and "E") were planted with which temperatures at depths of 20 and 40 cm were recorded. Temperatures were recorded hourly during steaming, and daily afterwards.

Results

The compost temperature recorded up to the time of steaming was 0.5 to 1.2°C, without marked fluctuations. It was obvious that in the given conditions, i.e., considering the almost frozen material and the low temperature of the environment, no self-heating would set in, without help from outside. (The ambient temperature fluctuated between -5° and -10°.) The temperature of a compost heap weighing 15 tons can be raised 1°C at the most by 8,000 – 10,000 kcal provided by steam, without taking into account the loss of heat to the surrounding atmosphere.

Comparison of the temperatures recorded in "A" and "B" in the course of steaming shows a rising trend in "A" only. No temperature changes were recorded during that time in "B."

At the site of steam inlet the temperature rose, after one heating, 30 times as high as the initial temperature of the compost. The peak temperature was recorded at a depth of 65 cm, indicating that favorable conditions arose at this depth for intensive microbial development. The smallest temperature rises were recorded at 20 cm below the surface, where considerable heat losses to the atmosphere may be assumed, and at 80 cm depth, where most of the steam condensed. The temperature curve after steaming indicates that a center of microbial activity actually arose in "A", at the depth of 65 cm, since at this site the temperature continued to rise for some time after steaming was discontinued. Consequently, it may be assumed that

TABLE 1. Temperature changes in "A" and "B" during steaming (in °C)

	"A"				"B"			
Depth, cm	80	65	40	20	80	65	40	20
1	10,5	14,8	5,5	4,2	-0,6	-0,7	-0,7	+0,2
2	10,5	14,8	6,2	4,8	-0,6	-0,7	-0,7	+0,2
3	10,5	14,8	6,8	5,0	-0,6	-0,5	-0,6	+0,2
4	11,0	16,4	6,9	5,4	-0,6	-0,5	-0,5	+0,4
5	12,3	19,8	7,9	6,2	-0,6	-0,5	-0,5	+0,4
6	13,5	22,4	9,2	6,9	-0,6	-0,5	-0,5	+0,4
7	15,0	25,2	12,6	8,2	-0,6	-0,5	-0,5	+0,4
8	16,5	27,8	16,6	9,8	-0,6	-0,5	-0,5	+0,4
9	17,8	28,9	18,4	11,8	-0,6	-0,5	-0,5	+0,4
10	19,0	31,6	20,4	14,1	-0,6	-0,5	-0,5	+0,4
11	19,8	32,6	22,6	16,2	-0,6	-0,5	-0,5	+0,4
12	20,5	33,4	26,7	19,1	-0,6	-0,5	-0,5	+0,4
13	21,0	33,6	26,6	20,2	-0,6	-0,5	-0,5	+0,4

the bacterial breakdown induced by heating the substrate warmed up, in turn, the surrounding layers, where the same process set in. This is substantiated by the proportional temperature rise in the surrounding layers. During the last 8 hours of steaming the temperature in "A" rose at an average rate of 1.5°C per hour (Table 1). In the 8 hours after steaming the temperature continued to rise by 0.3 to 0.5°C per hour (Table 2).

TABLE 2. Temperature course in "A" after steaming

	Depth, cm			
Hours	80	65	40	20
	Temperature, °C			
1	21,-	34,4	28,6	24,-
2	21,2	34,6	29,-	24,2
3	21,5	34,6	29,4	24,3
4	21,7	34,8	30,4	25,6
5	22,-	34,6	30,4	26,-
6	22,-	34,5	30,6	26,-
7	22,-	34,8	31,-	26,4
8	22,-	34,8	30,2	26,5

TABLE 3. Temperature course in "A" and "B" after steaming (in °C)

	"A"				"B"		
	Depth, cm						
Day	80	65	40	20	65	40	20
2nd	18,1	26,9	25,3	22,6	0,2	0,4	0,8
3rd	15,1	22,5	18,6	17,2	0,8	0,8	0,7
4th	12,5	18,4	15,1	13,4	1,2	1,4	1,8
5th	11,1	16,5	13,2	11,7	1,8	2,4	2,7
6th	10,0	15,0	12,1	10,5	2,4	3,3	3,8
7th	9,4	14,4	12,0	11,0	2,4	3,2	4,8
8th	9,0	14,2	11,2	9,0	3,0	3,8	4,8
10th	9,0	13,2	10,4	8,5	4,8	5,0	4,8
11th	8,9	12,8	10,4	10,0	6,0	6,0	6,1
12th	8,8	12,4	10,5	9,4	6,4	6,4	6,4
14th	8,4	12,2	10,2	9,0	8,9	8,2	8,4
15th	8,0	11,8	9,6	8,5	10,0	9,8	9,4
17th	7,0	11,0	8,8	8,0	11,8	10,8	9,8
19th	7,0	11,0	8,8	8,0	12,8	10,9	9,8
20th	7,5	11,2	9,2	8,3	13,2	11,1	9,9
21st	7,3	10,6	9,4	8,6	13,2	11,1	9,8
22nd	7,5	10,8	8,9	7,9	13,2	11,1	10,1
24th	7,3	10,6	8,4	7,9	13,3	10,8	9,7
26th	7,4	10,6	9,4	8,6	13,4	11,7	10,4

With progressive digestion of the compost, temperatures rose in "B" (Table 3), and dropped in "A". Comparison of temperature changes in "A" established that during the 26 days after steaming the temperature dropped at an average daily rate of 0.9°C, while rising in "B" at the rate of 0.5°C per day.

As is evident from the tabulated data, the unequivocal effect of a single heating-impulse is reflected at both ends of the compost pile by the temperatures recorded 26 days later (10.6°C in "A", and 13.4°C in "B"), and indicates compost digestion. The general temperature curves are given in Figure 2.

In order to prove that the heat evolves in and is irradiated from a central point into the surrounding layers, additional thermometers were buried at depths of 20 and 40 cm, in "C", "D" and "E" 5 days after steaming was completed. Although the initial values of heat diffusion from "A" to "B" were not ascertained, a trend of rising temperatures at the above mentioned three points and two depths could be traced and, in the course of time, a general warming-up of certain points farthest from the steamed site "A" could be registered.

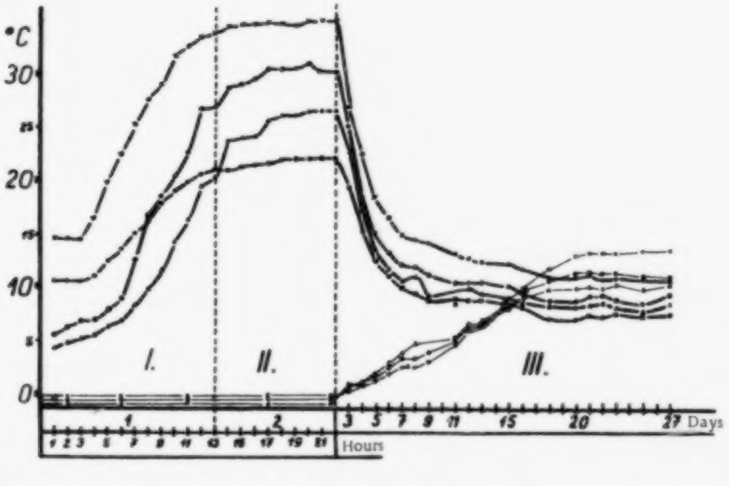


FIGURE 2. Temperature curves in warmed-up compost.
Stage I. Steaming time (x-scale in hours). Stage II. Time of temperature rise in zone "A" after steaming (x-scale in hours). Stage III. Time of temperature fall in zone "A", rise in in zone "B" (x-scale in days):

- ■ - ■ - Temperature at 80 cm depth
- x - x - Temperature at 65 cm depth
- ○ - ○ - Temperature at 40 cm depth
- ▲ - ▲ - Temperature at 20 cm depth

TABLE 4. Temperature changes in "C", "D", and "E" at depths of 40 and 20 cm, recorded from the 5th day after steaming was completed (in °C)

Day	"C"		"D"		"E"	
	40	20	40	20	40	20
6th	15.0	14.0	15.5	11.5	8.2	7.7
7th	14.5	14.0	15.0	11.5	8.9	8.8
8th	15.0	13.3	16.5	11.5	9.8	8.2
10th	17.6	13.0	16.5	11.5	10.2	8.2
11th	18.5	13.5	19.5	13.5	12.0	9.6
12th	18.5	14.0	19.5	14.0	12.0	9.8
14th	18.6	15.1	19.7	15.2	13.0	11.4
15th	18.0	14.4	19.5	14.5	13.4	11.4
17th	18.0	14.5	20.0	15.0	14.8	12.8
19th	18.0	14.0	20.0	14.5	15.4	12.8
20th	20.0	15.1	20.1	14.0	14.8	12.4
21st	20.1	15.2	20.1	14.2	14.8	12.4
22nd	21.0	16.6	20.5	14.5	15.2	13.2
24th	21.5	16.3	21.6	14.8	16.8	13.0
26th	22.1	16.9	22.5	16.2	18.1	14.3

Spot measurements confirmed that deep in the middle of the compost heap temperatures reached their maximum.

As we approached the statistical processing of the data obtained, we were interested in the elucidation of three fundamental points connected with the heat center that had formed at a depth of 65 cm.

In the first instance, dependence of the temperature rise (Y) upon the time of steaming (X) in the first stage, at "A". The calculated regression equation

$$Y = 3.1\ X + 2.6$$

with the mean deviation 5.3, and the T-value = 17.2 (the tabulated value of T at P = = 0.01 and n = 13 equals 3.06) indicate that the regression coefficient is highly significant. Consequently, it may be stated that the temperature rise in stage I, at "A" is markedly dependent upon the heat impulse supplied.

The second point was solved as reciprocal dependence of the temperature rise in stage III at "B" (Y), upon the temperature rise in "A" (X), i.e., on the effect of the heat impulse. The reciprocal dependence may be expressed by the regression equations

$$Y = 0.597\ X - 7.89$$

$$X = 1.25\ \ Y - 16.05$$

and the correlation coefficient 0.857. The T-value of the regression coefficient amounts to $T_y = 5.58$ and $T_x = 5.74$; the T-value of the correlation coefficient is 2.84 (provided that in all three values P 0.01 = 3.06, and P 0.05 = 2.18). Accordingly, it may be claimed that the reciprocal dependence mentioned is significant to highly significant.

The third point was also solved as reciprocal dependence of the temperature rise in "B" in stage III (y) upon the temperature drop in "A" at the same stage (X). This reciprocal dependence is expressed by the regression equations

$$Y = 0.34\ X + 1.87$$

$$X = 0.89\ Y + 9.04$$

and the correlation coefficient 0.54. The T-values of the regression coefficient are $T_y = 2.8$, and $T_x = 2.7$, and of the correlation coefficient, $T = 2.7$ (when $n = 20$, and $P\ 0.05 = 2.09$ and $P\ 0.01 = 2.86$). Hence, it may be stated that the dependence is significant and approaches high significance.

Discussion

As evident from the estimates, it is possible to speed up compost ripening in favorable conditions by a single heat impulse, when otherwise no microbial processes could take place on account of the low primary temperature.

Appropriate composition of the compost and adequate size and shape of the compost heaps constitute the prerequisites for successful application of the method.

Application of this method for composting material deficient in useful organic matter, or lacking other material indispensable for microbial nutrition would be wasteful, since no heat would evolve, and such a compost would not warm up in the most favorable conditions (in summer).

Composts prepared from too finely crushed material or heaped so that their surface is large in relation to the volume, are subject to considerable loss of heat. Therefore, their animation with the described method seems highly improbable. Conversely, too coarse components with a relatively small surface would not allow the oxygen — carbon dioxide exchange between the atmosphere and the air in the compost heap and, consequently, would not warm up effectively by biological processes.

Bibliography

1. **Glathe, H.** Biologische Vorgänge bei der Kompostierung von Müll (Biological Processes at the Composting of Refuse). — International Congress, Wageningen. 1959.
2. **Imshenetskii, A. A.** Ob dvizhenii protsessov vyzivaemykh mezofil'nymy i termofil'nymi bakteriyami. Mikrobiologiya. 10. 4, pp. 385 — 395. 1941.
3. **Kaila, A.** Humification of Straw at Various Temperatures. — Suomen moataloustieteellisen searan jubkai suja, 78. pp. 1 — 32.
4. **Novák, B.** Tvorba humusu ve statkových hnojivech. — Sborník ČSAZV - RV, 4 (XXXI), 6 — 7, pp. 809 — 822. 1958.
5. **Novák, B.** Mikrobiologické pochody při tvorbě a rozkladu humusu s hlediska statkových hnojiv. — Sborník ČSAZV - RV. (XXIX) 9 — 10. pp 999 — 1031. 1956.
6. **Novák, B.** and **F. Lobl.** Vliv ksylíku na zrání statkovych hnojiv. — Sborník ČSAZV - RV (XXXI) 4, 8. pp 955 — 962. 1958.

MOBILE HAMMER MILLS FOR PREPARATION OF REFUSE SAMPLES

By G. Rollé, EAWAG, Zurich

The various difficulties encountered in the analysis of household and industrial refuse have been reported here earlier.

Why should the refuse be analyzed?

The amount of refuse – a mixture of all imaginable materials – steadily expanding owing to its lowered volumetric weight, must be disposed of in a safe, hygienic and inexpensive way, and if possible, reclaimed. This can be achieved by suitable processing in plants especially built for the purpose. Without entering into details of various means of disposal it is evident that a more accurate knowledge of the material to be processed is required. Its characterization must, therefore, be included in the processing plan. The system to be chosen will depend, apart from other factors, upon the quality of the refuse. Hence, refuse analysis was primarily imposed by necessity, although scientific interest also led to development of these analyses.

Sampling is fundamentally the same, for practical as for scientific analyses. Correct sampling of the material is most important, whether for chemical or for physical analysis. And precisely at this point serious difficulties arise. How can a reliable average sample be obtained from this heterogeneous mass consisting of aggregates greatly varying in size? The sample should represent as nearly as possible the actual composition of the entire material. This is an obligatory condition for the validity of the sample analysis and its results.

If the regional or town refuse is to be analyzed, facilities for sampling in accordance with the above-mentioned conditions should be available. Reliable sampling can be achieved if the analyses are carried out in a plant equipped with a suitable comminuting device.

But in practice, refuse characterization is more often required for plant planning, in which case correct sampling is not easy. These preliminary analyses may be decisive in the planning of the entire installations and dimensions of the refuse-disposal or reclamation plant.

This problem was usually solved by taking several cartloads of the material to an established plant and have it processed there. In most cases, however, there was no other choice but to sample different groups by hand and weigh them. This procedure, though providing a rough general estimate of the collected refuse, does not permit more detailed examinations, such as chemical analyses and determination of caloric values.

For precise analysis, adequate means of crushing and homogenizing the test material should be available everywhere and at all times. This need led to the development of a mobile comminuting device.

The mobile hammer mill was put into operation by EAWAG in May, 1963.

1. Description

A single-rotor hammer mill is mounted on a single-axle trailer and driven by a stationary VW-engine. The entire unit was assembled by the mill manufacturer, **HAZEMAG m. b. H., Fed. German Rep.**

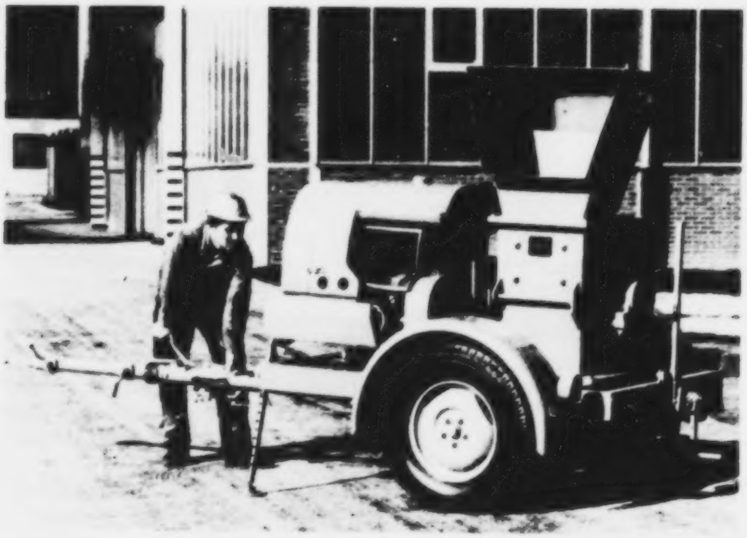


FIGURE 1.

1.1 Mill

The principal component of this mobile comminuting device is the hammer-mill type

UNIROTOR 490/380

manufactured by the aforementioned firm. The mill weighs approx. 700 kg and is sturdily built. It is equipped with a feed funnel that allows the material to be introduced from the side. Comminuted material falls out below, freely or through a knife grate; 48 hammers between 7 disks fly past the grate bars at a distance of 6 - 10 mm. These bars of 30×20×375 mm with a 10×15 mm groove lie on lateral guides. The discharge funnel is kept open and rests on an iron frame, also fitted in the groove. Iron blades can be introduced in this frame. The shredded matter is thus prevented from falling through freely and must pass through the knife grate.

The material to be comminuted is not only crushed between hammers and grate bars. The last two bars (in the direction of rotation) immediately in front of the discharge funnel have 5 sturdy steel spikes welded to them. These spikes lie exactly in the plane of the disks carrying the hammers, i.e., the hammers pass between these spikes. The shredding effect is thus considerably enhanced.

Maintenance of the mill is quite simple. The sturdy rotor bearings are provided with lubrication nipples. The milling chamber is easily accessible since both the hopper and the upper cover can be turned sideways. Grate bars, closing plates, etc., are easily mounted.

1.2 Drive

The mill is driven by a petrol engine. A VW-industrial engine (1,200 cc, 30HP) with a centrifugal governor is suitable. The torque from this 4-cylinder opposed-piston engine is transmitted by a clutch to a V-belt pulley. Four V-belts drive the rotor of the hammer mill. Access to the engine is good, thus ensuring easy servicing and maintenance.

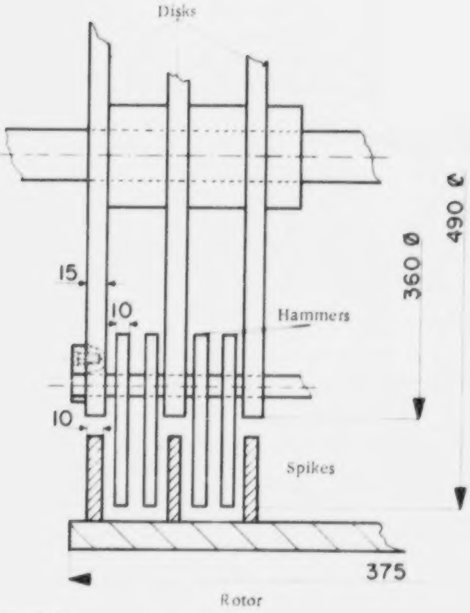


FIGURE 2.

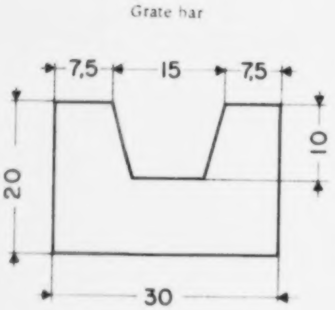


FIGURE 3.

1.3 Chassis (Trailer)

The mill and engine are mounted on a U-shaped steel frame. A rubber-spring axle (ROSTA system) was fixed so that the resulting shaft load amounts to approximately 80 kg. The wheels are fitted with 6.50×16 tires. The shaft was designed so as to allow the trailer coupling to be set at various heights above the ground. Besides, the trailer eye can be replaced by a ball coupling so that the trailer can be attached to various vehicles. On the U-shaped steel frame jacks are fixed two in front laterally, and one at the rear in the center of the chassis. With these, the horizontal, stable working position of the mill is assured on any terrain.

The road properties of the trailer are excellent. Bouncing is prevented by good rubber shock absorbers. Directional stability is ensured by the comparatively high shaft load which is no drawback with heavy traction vehicles. The trailer is provided with overrunning brakes that can also be actuated by a hand-brake lever for parking.

2. Specification

2.1 Mill (Type 490/380)

Opening of hopper	380×300 mm
Housing width in the direction of rotor axis (inner)	380 mm
Housing length in the direction of rotor diameter (inner)	510 mm
Rotor diameter	360 mm
Rotor diameter with extended hammers	490 mm
Number of hammer lanes	6
Number of hammer bolts	4
Number of hammers	48
Hammer dimensions	120×50×10 mm

Grate bars, dimensions	30×20×375 mm
Discharge opening	250×340 mm
Normal speed	ca. 3,800 r.p.m.
Peripheral velocity	ca. 100 m/sec

2.2 Drive

VW-Industrial engine, 1200 cc, 30 HP with centrifugal governor.

2.3 Chassis

Width over wheel housing	1,780 mm
Length of frame with jacks	ca. 2,200 mm
Overall length including shaft	ca. 4,000 mm
Overall height with hopper	1,970 mm
Height from ground to opening of hopper	1,500 mm
Height from ground to lower rim of frame	560 mm

3. Modifications

This mobile hammer mill may be considered a prototype, especially as far as engine and chassis are concerned. Taking this into account we found that in the main, the entire outfit functioned perfectly right from the start. Certain details had to be changed in order to diminish friction and, especially, to simplify operation and maintenance.

3.1 Mill

For effective comminution the grate must be fitted with baffles. This can be done by inserting flat steel strips of different thicknesses in two parallel grooves. However, this arrangement proved unsatisfactory because in the course of milling the thinner strips slid under the thicker ones and got jammed. The grate was therefore replaced by bars described in 2.1, of equal thickness.

3.2 Drive

The dynamo of the VW-engine had to be covered in order to protect it from the dust raised during operation of the mill. For the same reason the air inlets of cooler and carburetor had to be modified, since both air filter and cooling ribs on the cylinders were clogged by dust.

3.3 Chassis

The three supports fixed to the U-shaped iron frame proved inadequate for the load. The support tubes mounted in the front soon bent and could be operated only with great difficulty. They were therefore replaced by jacks, which are also useful for coupling to the traction vehicle. The rear jack with the open rack also proved too weak for the load and especially for rough operation in the field. This part was also replaced by a sturdier jack with guided rack.

The originally open U-frame of the chassis had to be covered with sheet metal, for two reasons:

The pieces of paper flying out from the discharge funnel were sucked into the air inlet port of the VW engine. The inlet port was thus soon clogged, and the engine exposed to the danger of overheating.

When loading the hopper large pieces fell through the frame and into the milled samples.

As earlier mentioned, these modifications helped to simplify operation and maintenance. The fact, often established in large plants, holds true also in this case: the equipment for refuse treatment can never be too heavy or too sturdy; on the contrary, all too often the implements are too weak, or too lightly built.

4. Operation

4.1 Servicing

The trailer is detached from the vehicle and adjusted to a horizontal position with the aid of the three jacks. In the field (on refuse heaps) a thin sheet should be placed under the discharge opening in order to obtain samples of the milled material free from admixtures. After starting the engine, a clutch engages the rotor, and when the required number of revolutions is attained (approximately within 20 seconds), milling may begin.

4.2 Feeding the mill

Since the mill is not built for continuous operation, the material is shoveled in. This permits large metal pieces, such as flatirons, steel reinforcement, castings, etc., to be removed by hand since hammer-mills cannot avoid them (as with deflection plates). Apart from that, it is amazing how efficiently this small mill comminutes everything: tin cans (up to 5 l capacity), stones, wood, bones, bottles, etc., together with paper, vegetables, cardboard, and synthetic material. Textiles, on the other hand, are not effectively comminuted, only torn to pieces.

Large tin cans, bones, cartons, etc., may occasionally obstruct passage through the hopper. These materials must be removed when the mill is at a standstill.

4.3 Sampling

The comminuted refuse collected under the mill must be mixed. Usually, the trailer is pulled away and the material turned over. As a rule, at least 1 m^3 of milled raw material is required for sampling. In addition, it is important to take into account possible separation and segregation in refuse-collecting vehicles with different load and compacting principles, in order to obtain a truly representative average sample from each vehicle. This factor actually determines the value of the sample. A certain degree of experience is essential in order to avoid gross mistakes in sampling. The ever increasing heterogeneity of the material makes sampling a ticklish job.

The comminuted material is thoroughly mixed again before sampling (a certain separation by weight during milling is unavoidable).

4.4 Mechanical disorders

Incidence of mechanical disorders is very low. Properly fed (taking care not to load it with large cases, pieces of metal, etc.), the mill can work for several consecutive days without being opened, even once.

It happens, however, that larger pieces of tin cans settle around the spikes, obstructing the passage, and thus leading to accumulation of material in the mill. The latter is easily opened and cleaned. If extensively blocked, it might be necessary to remove some of the grate bars. With the modifications mentioned this operation is simplified. Interruptions of this kind do not last more than five minutes.

The hammer-mill is subjected to heavy stress. Textiles are especially trying, their tearing causing strong blows which, although dampended by the belts, also affect the driving unit. But, since the engine has enough reserve power and the centrifugal governor reacts quickly, the full speed of the rotor is reestablished after a few seconds.

4.5 Wear and tear

4.5.1 Mill

On the basis of past experience no serious damage to the mill is to be expected if the latter is properly manipulated. Of course, the grate bars may be bent or broken by metal pieces. Hammers can be similarly damaged. Such damage can be easily prevented by careful loading.

Similar damage occurs also in the large mills installed in refuse processing plants.

Wear and tear of hammers: the hammers had to be turned round after a working period of 25 hours; their service-life is approximately 50 hours. So far, disks and bearings show no wear and tear.

4.5.2 Drive

The driving unit has adequate reserve power. In normal operation the engine is not subject to excessive strain. Nevertheless, it cannot be expected to serve for as long as other VW-engines. This, especially on account of the intermittent operation (standstill/full output), and because of the rest periods between service (inner corrosion, especially of bearings, slides etc.). Petrol consumption fluctuates between 7 and 12 liters per hour.

The clutch, located between the engine and V-belt pulley, is subjected to considerable strain, and maintenance costs should be taken into account here, too.

4.5.3 Chassis

The rubber springs which need no maintenance are, as yet, in perfect condition, notwithstanding the muddy fields in which the mill was operating. The cable-operated hand-brake needs maintenance. The overrunning brake works reliably but its adjustment is very complicated.

In conclusion it can be said that this mobile hammer-mill is a valuable implement for the analysis and characterization of refuse. It enables sampling according to requirements at any time, on any site. It is a reliable implement and has fulfilled all expectations.

INAUGURATION OF A LARGE COMPOSTING PLANT IN ROME

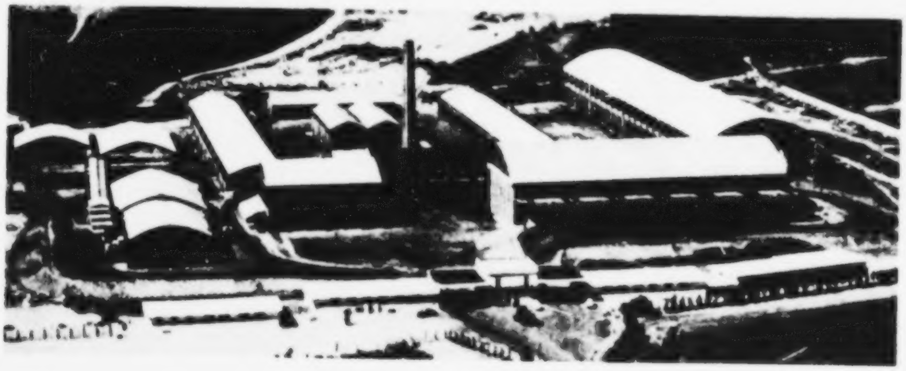
By Ing. V. Stahlschmidt, Zurich

The largest and most up-to-date composting plant in Europe was inaugurated with great solemnity in Rome on 29 Oct. 1964, by Cardinal Traglia and Mayor Petrucci, in the presence of numerous representatives of the Capitol authorities and guests from Italy and abroad.

The plant is a cooperative undertaking of the communal authorities and a private enterprise, Societa Laziale Imprese & Appalti (SLIA), and was built by Breda, Milano, on the principle of the Dano-stabilizer system. The five biostabilizer units have a capacity of approx. 250 tons in 8 hours. In addition, there is an incinerator (Saronno system) with a capacity of approx. 50 tons in 24 hours. The solid refuse of about one quarter of Rome's population, corresponding to approx. 600,000 inhabitants, is treated here. The municipality is responsible for the collection service in the center of the city, while the rest of the metropolitan area is divided into four sectors, each serviced by a different contractor. The western sector is serviced by SLIA and the garbage collected there, together with one quarter of that collected in the center of the city, is processed in the new plant, 18 km west of the city center.

In Rome, garbage is collected daily, even on Sunday. The wastes are removed from every apartment by the collectors, packed in strong sacks, and carried to the vehicle. The sacks are then mechanically lifted, emptied and shaken out. They are washed and sterilized regularly. This extraordinary service is time-consuming and each vehicle transports only one load per day. Consequently, approximately hundred loads of refuse arrive at the plant between 12 a.m. and 3 p.m.

The spacious bunkers allow for the simultaneous discharge of ten vehicles. The refuse is transferred to each stabilizer unit by a plate conveyor and two belt conveyors, and moves past two magnets (one above the belt and one a magnetic drum). The iron scrap is carried by two conveyors to a special silo. After three days, on the average, the comminuted, digested and now harmless material, completely changed and reduced to one quarter its initial volume, passes from the drum into five vibration screens, where it is sifted into three fractions.



The coarse fraction, approx.10%, is conveyed to the incinerator, the fine fraction, approx. 50%, is the ready compost, and the middle fraction, approx. 30%, is milled before being added to the compost and leaving the plant. The digestion loss amounts to 10% of the initial weight.

The compost is stocked in thin layers in a storage hall 150 m long. Layering is performed with the aid of a conveyor belt, 150 m long, fitted with a continuous release mechanism, and from it the compost passes onto two transverse conveyor belts, also mobile, by means of which it is evenly spread over the entire width of the hall.

The five biostabilizer units with the auxiliary machinery and reserve space for future installation of a sixth unit are contained in a hall 80 m long and 40 m wide. From the control room, erected on a raised level in the middle of the hall, the plant manager can survey and control the entire operation, as well as instruct the eight employees by telephone. The plant has been in operation since February 1964.

At the same time, another plant was inaugurated in another sector of Rome. The plant was built by Soc. Agricola Recupero Residui (SARR) for the production of pig feed. In contrast to earlier factories of this kind, where bread and other food remnants were reclaimed, here, all indigestable or injurious materials are separated by means of sieves, magnets, or by hand. Thus, paper, rags, bottles, ceramics, plastics, shoes, metal, ash and coarse parts are picked out, while the remainder is pasteurized in steam and sold as pig food. This plant employs three times as many employees as the SLIA plant.

Part of the plant are also garages for 240 refuse-transporting vehicles, workshops and installations for automatic car-washing.

The employees have ample shower rooms and the services of an excellent canteen and cafeteria.

The city of Rome may be rightly proud of this modern establishment .

III INTERNATIONAL CONGRESS OF THE INTERNATIONAL RESEARCH GROUP FOR REFUSE DISPOSAL (IRGRD), ON THE REMOVAL AND RECLAMATION OF DOMESTIC SOLID WASTE

The Third International Congress of IRGRD will take place in Trento (Italy) on 24 - 29 May 1965. The congress is organized by "Associazione Nazionale di Ingegneria Sanitaria".

According to the program, there will be lectures and discussions on the following subjects

I. Effect of solid refuse dumps on surface and groundwater.
II. Sanitary landfill with solid refuse.
III. Potential and limitations of different procedures within the general problem of refuse disposal.
IV. Special aspects of the incineration technique
a) incineration plants with utilization of the heat evolved
b) incineration without utilization of the heat evolved
c) refuse incineration and air pollution control.
V. Special aspects of composting techniques
a) treatment of refuse by mechanical shredding and screening
b) importance of predigestion in composting
c) odor problems in composting.
VI. The sewage-sludge problem.
VII. Present state and future development of refuse disposal in Italy.

Apart from lectures and discussions, visits to recently installed refuse-processing plants are planned.

For programs, registration and further information please apply to
Gruppo Internazionale di Studio sui Rifiuti Urbani Solidi,
Segreteria del Congresso, Via Belenzani 3, Trento (Italia).

DISCUSSION

We again remind our readers that they may state their views freely (publishers accept no responsibility) in this Information Bulletin. Concise contributions should be sent to the secretariat: Physikstrasse 5, 8044 Zurich.

Contribution by Dipl.Ing. V. Stahlschmidt, Zurich

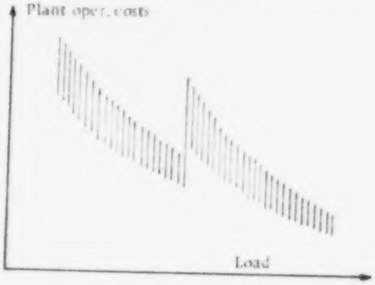
The investigation conducted by Dipl. Ing. K. Wuhrmann, EAWAG, Zurich (Information Bulletin No. 20) on the significance of the size of the refusal-disposal plant in rural areas is theoretically very interesting. It confirms that the advantages of a larger central plant may compensate for the costs of longer transport routes. On the basis of this principle, several companies have been formed in "rural areas" (for example the Zurich Highland, the right bank of the Zurich Lake and the left bank of the Zurich Lake). The utilities companies mentioned here were founded after comprehensive studies which showed that regions seemingly comparable in topography, collection service, transport routes, etc., were so different that they could not be summarized in a scheme or diagram. The results of the investigation mentioned are nevertheless summarized in 3 diagrams (page 49), which, without justification, claim general validity and accuracy.

How did these sharply defined and smooth curves originate?

1. Each curve is determined by only two points (for example, the operating costs for a number of inhabitants of 33,000 or 100,000, respectively).

2. These points are determined by rough estimations, and a quotation from an ominous investigation report is most appropriate here: "The arithmetical summations of roughly estimated positions produced an illusory accuracy that must have been misleading insofar as the actual cost determination was concerned".

3. The shape conferred on the curve between each of two points (or intervals) is certainly not correctly chosen. It is suitable for a certain plant size, for which the operating costs are, approximately, inversely proportional to the load (at low loads the costs are high, and vice-versa), but as soon as the capacity limits of a plant are exceeded the costs will rise abruptly, because a larger plant will be required whose capacity will not be fully utilized. The plant sizes being, of necessity, limited, the correlation will be as shown in the accompanying diagram.



It should be pointed out that the type designations have not been well chosen since each type comprises two kinds of plants that cannot be compared. The composting plant, which processes sewage sludge, requires additional sludge; whereas incinerators cannot process sewage sludge under the described conditions. In conclusion, it must be stated that for all practical purposes the diagrams are not valid; neither for a comparison of two procedures, nor for determination of plant-operating costs.

INFORMATION BULLETIN NUMBER 23
May 1965

ADVANCES IN SOLID WASTE RESEARCH IN THE UNITED STATES

By W. A. G. Weststrate, Amsterdam

"The well-known aptitude of modern cities to drown in sewage is exceeded only by their talent of suffocating under a blanket of waste and rubbish".

This is the opening sentence of a report published in the American "Public Health Reports" on the conference dealing with research on refuse disposal held in Chicago in December, 1964. This "National Solid Waste Research Conference" was grandiously organized by its sponsors, by The American Public Works Association, and The Environmental Sciences and Engineering Study Section of the U.S. Public Health Service. The ever growing problems of refuse disposal were thoroughly debated by the 170 participants, carefully chosen from all parts of the U.S.A. The purpose of the three-day long deliberations was to encourage intensive research work aimed at finding a solution to the problems. The selection of the participants is clearly an indicator of the interest the problem of refuse disposal has aroused in the United States. Of the 170 participants no less than 55 were college teachers; the health services were represented by about 25 persons, and many municipal employees and industrialists took part in the congress.

The report continues "The volume of solid waste has increased in a higher proportion than the population, while the space available for waste disposal has diminished".

The inescapable result is that the dustbin, the garbage and junk heaps have left the private garden, the garage and the loft, and have come out into the public eye. What, so far, had been a private nuisance has now become a great public worry. Recurring crises in waste disposal have aggravated the situation to the point that compelled communal authorities everywhere to search for ways and means of finding a solution. However, the amount of research on the handling of solid waste — a 3-billion-dollar enterprise — so far, has been rather negligible.

Although an annual allocation of 100 million dollars for research in an industry of this size would not be unusual, the subsidy for the entire research in the field of nonradioactive solid wastes is limited to the sum of 200,000 dollars allocated by the Ministry of Health, or is financed by other public institutions, universities, private enterprises and trade unions."

Professor J. E. McKee of the University of California mentioned in his opening address that in Los Angeles County the dry weight of liquid sewage amounts to 195 g per inhabitant per day. Municipal waste amounts to about 760 g dry mass per inhabitant per day, to which are added 125 g industrial waste. Hence, the total dry mass of solid waste per inhabitant per day amounts to 885 g.

The wastes contained in the air of Los Angeles County amount (without carbon dioxide and water) to 1470 g dry mass per inhabitant per day. Of these, 84% are the product of motor vehicles and 16% of stationary sources. In this connection, Prof. McKee warned against further loadings of the atmosphere with waste, especially

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from refuse-incineration plants, because the air in modern cities already constitutes "the main highway for waste disposal."

The following aspects were studied by four groups of congress participants:

A. Quantity and properties of solid waste
B. Collection, storage and transporation of waste
C. Disposal of solid waste
D. Treatment, conversion and utilization of solid waste.

On the subject of composting, two European lecturers were invited (the only non-Americans at the congress): Dr. Cord Tietjen of Braunschweig-Völkenrode, who dealt with conservation and field testing of compost, and Ir. W.A.G. Weststrate of Amsterdam, who spoke on composting in general.

It is impossible to discuss in a brief article the 11 papers read at plenary sessions and the 16 lectures delivered in the study groups. Attention was paid also to industrial and agricultural wastes. One of the speakers mentioned that the canning industry in California alone produces annually 500,000 to 600,000 tons of waste. Difficulties arise also in connection with the increasing number and size of pig-breeding farms. So far, the number of animals per farm does not exceed 15,000, but within ten years certain farms may be expected to breed as many as 100,000 animals. We are already faced with the problem of disposal of pig excreta. In the discussion one of the participants mentioned the difficulties encountered by a chicken farmer in disponing the chicken dung of his 320,000 hens. The problem of old motor cars was also discussed.

The general trend of steadily increasing amounts of solid waste was pointed out, and the cities and states warned of the rapidly mounting quantities to be expected. Therefore, planning of disposal requires population estimates for the next twenty years, and that is no mean task for a state like California, for instance, where the population is expected to increase during this period from 16 million inhabitants (1963) to 32 million inhabitants (1980).

In his concluding address, the chairman of the conference Prof. Dr. Ross E. McKinney of the University of Kansas exhorted the younger participants to engage in research of the problem, and stressed the absolute necessity for coordination between science and practice.

We recommend the study of the "Proceedings," which contain the complete texts of the papers, discussions, etc., of this important conference. * Various papers throw new light on long-standing problems in Europe also.

However, the most important aspect of the conference remains the common endeavor of scientists, laymen, communal authorities, industrial bodies, etc., to deal thoroughly with the problems of solid waste disposal.

INVESTIGATIONS INTO UTILIZATION OF URBAN WASTES IN SOUTH AFRICA

By P. R. Krige, National Institute for Water Research of the South African Council for Scientific and Industrial Research, Pretoria

In the last 15 years increased industrial development has taken place in South Africa, and as a consequence the areas of city housing have considerably expanded. In many cases municipal authorities were faced with serious problems in connection with the hygienic disposal of municipal wastes.

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* Available from the American Public Works Association, 1313 East 60th Street, Chicago (Ill.) U. S. A.

This development made greater demands upon agriculture, and the Soil Conservation Board expressed its concern about the lack of organic material suitable for agricultural utilization.

Since these facts have a direct bearing on the economy of the country, the CSIR and the Soil Conservation Board agreed to investigate all the aspects of municipal waste disposal.

It was recognized that municipal wastes, domestic refuse, sewage sludge and night soil are neglected potential sources of humus. The utilization of this waste would be of national importance, provided it were possible to develop industrial methods capable of supplying a final product that would also satisfy the health authorities.

Although the composting of waste may be of primary importance, the salvage and re-use of economically important substances present in municipal and industrial waste is an aspect that cannot be ignored.

The experimental plant was designed by CSIR and provided for the carrying out of a comprehensive investigation programme. The results are set out in full in the CSIR Research Report No. 211[1], from which brief excerpts are given below.

1. There are various methods of suitably mechanizing the critical and difficult stage of initial biological decomposition, the stabilization stage, in order to
   a) ensure aerobic conditions at all time and thus prevent unpleasant odors and fly-breeding,
   b) promote rapid decomposition,
   c) dispense with manual labor and
   d) ensure continuous semiautomatic operation.
2. The system of rotating drums with attachments, designed by CSIR for research purposes, is suitable for fulfilling the four main conditions set out under 1.
3. Municipal waste can be processed entirely without the aid of additives. However, the addition of liquid sewage sludge or night soil has decisive advantages, marked in the first place by an improvement in the otherwise distinctly unfavourable C/N ratio of plain municipal waste. An addition of sewage sludge or night soil also increases the phosphate content of the waste.
4. The high water content of night soil and liquid sewage sludge obtained from settling tanks severely restricts the amount that can be added to municipal waste without increasing the moisture content of the mixture beyond the permissible limit. No more than 11 gallons of sewage sludge or night soil could be added to one cubic yard of crude screened refuse and 17 gallons to one cubic yard of sorted refuse. (1 gallon per cubic yard = 6 l/m^3).
5. The addition of sewage sludge or night soil is desirable in order to provide the biological organisms with indispensable nutrients during stabilization and maturation. The same nutrients serve later as nutrients for the plants when the maturated compost is applied to the soil. It is therefore recommended to devise a system according to which sewage sludge and night soil are partly dehydrated before they are added to the refuse. The addition of dry sludge from drying pits would serve the same purpose.
6. It is advisable to screen off fines from municipal waste before it is conveyed to the composting plant, to reduce wear of the plant. However, the fines can be added again in the maturation stage in order to transform organic components into humus and to kill off weed seeds.

   Whether this method of utilization of the screened fines is usable in winter depends on the amount of coal used as fuel by the community. It is quite possible that in certain months the screened material consists largely of coal ash and is comparatively worthless.
7. The quality of the compost and sewage sludge was investigated in regard to their content of bacteria and Ascaris ova, and it was found that the compost

marketed in the Republic of South Africa is relatively harmless from health aspects. Moreover, the mechanical plant of CSIR produced a compost consistently free from Ascaris ova.

In a controlled test the experimental plant was inoculated with Type I Poliomyelitis viruses. All the viruses were killed in the stabilization stage.

On the basis of the results of these investigations, a commission of public health experts, specially convened to direct bacteriological studies, made the following recommendations:

(i) Sewage sludge is safe for agricultural use only in the form of compost (as specified below).

(ii) Compost containing animal or human wastes can be regarded as safe only if the method of production ensures that the following criteria are satisfied: that a temperature of 60°C (140°F) throughout the entire mass has been maintained for a minimum period of 5 days and that the compost is not distributed for use until a further storage period of 35 days has elapsed.

(iii) It is recommended that a practicable method of evaluating the public health safety of such compost would entail regular periodic examinations for viable Ascaris ova. A safe compost should not contain any viable Ascaris ova.

Compost produced under controlled conditions can thus be considered safe from the public health aspect. Composting waste in suitable technical installations is therefore another safety factor in the hygienic measures at the disposal of the city engineer and of the municipal health officers. The various objections to the marketing of compost produced by utilizing sewage sludge are therefore not valid.

8. The cost of waste removal depends mainly on transportation expenses. A composting plant can usually be located much nearer to residential areas than a dumping site for refuse, because the composting plant does not constitute a health hazard and does not require much space. An important economic factor is the number of units operating in one place. The larger the number of units operating together, the lower the operating costs.

The figures in the following table, determined during the operation of the experimental plant, give a rough idea of the costs connected with the production of 1 cubic yard compost from 2.78 cubic yards untreated refuse (1 cubic yard = = 0.76 m^3). (The costs given in the table are additional costs compared with normal dumping of refuse).

COSTS OF PRODUCING 1 CUBIC YARD COMPOST
(Rand 1.00/cubic yard = DM 5,54/0,76 m^3)

	1 unit				3 units				5 units			
Distance* (miles)	2	7	12	20	2	7	12	20	2	7	12	20
Costs in Rand	1,66	1,30	0,93	0,34	1,36	0,80	0,53	-0,04	1,07	0,71	0,34	-0,24

* Average difference in distance between the distances from the collection area to the refuse dump and the distances from the collection area to the composting plant (1 mile = 1,609 km).

Factors taken into account in calculating the figures set out in the above table:

On the "credit" side

Savings in transport costs
Saving of unloading and stacking costs on the refuse dump
Income from utilizing of salvaged material

On the "debit" side

Costs of sorting and screening
Costs of removing fines
Costs of transporting final waste
Costs of removing final waste
Interest on capital invested
Amortization (50% in the first 10 years and 50% in the subsequent 20 years)
Maintenance
Labor
Power

The table shows that at a sales price of R 1.25 per cubic yard compost can be sold at a profit if more than one unit is operated, or if the saved transport costs do not accrue from 2 miles only or even less. If the saved distance of transported refuse were more than 20 miles, and provided more than three composting units were in operation, the refuse compost could be theoretically disposed of free of charge, and a small saving would still remain from the costs of unloading and stacking on the refuse dump.

Other factors that could further reduce the production costs but were not taken into account in compiling the table:

- completely mechanized pretreatment of the raw refuse, including pulverization of the coarse organic material before the refuse is conveyed to the composting plant;
- more effective salvage as a result of contracts with private enterprises;
- re-introduction of fines (if the fines screened off before composting contain sufficient organic substances, they can be re-introduced into the compost in the final stage).

Bibliography

Krige, P. R. The Utilization of Municipal Wastes. Report on the Processing of Urban Wastes in a Mechanized Composting Plant. – CSIR Research Report No. 211, Pretoria, South Africa, p. 71. 1964.

PROBLEMS OF REFUSE DISPOSAL

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By Dipl. Landw. A. v. Hirschheydt, EAWAG Zurich

Until a short time ago "waste" and "waste and sewage-sludge disposal" were still generally discussed, whereas now it is quite clear that these terms do not adequately convey the extent of the problems involved. Even the term "economics of communal waste" does not define the extent of the entire task, because it fails to include the industrial wastes. We can therefore speak only very generally of "economics of waste disposal" or "waste disposal." The authorities responsible for the maintenance of local cleanliness and for implementation of the respective laws, should also be in charge of the general refuse disposal.

It follows that in most cases a "waste disposal plant" in the current sense, or as hitherto understood, cannot cope with the actual requirements. Accordingly, I intend to discuss the steps that may lead to a sensible solution, i.e., answer the requirements of the waste disposal task, while keeping the expenses at a minimum. An exhaustive description of all the possibilities is presently out of question, for reasons of space alone. Moreover, I am primarily concerned with advancing suggestions that will stimulate discussion, especially of those aspects that have received much less attention in the professional press and at meetings than the aspects of processing, choice of procedure and technical aspects in general. It is presumed that the processing techniques, etc., are well known, so that the accompanying bibliography will suffice.

The problem, then, is "refuse disposal" not limited to certain types or groups of material, nor excluding any; and given this wider concept, it is evident that different planning will be required.

Until recently, a composting plant that managed to process the domestic refuse, and sewage sludge, or at least all or part of the communal sewage sludge, could be considered an innovation and a workable solution for the communal waste-disposal problem, although disposal was not complete, since a large part of the screened refuse had to be dumped. Today, such an outfit proves most inadequate, since in addition to the domestic waste industrial, commercial and bulky refuse must also be processed. Although household refuse still constitutes the larger proportion of the total refuse, it need not always determine the procedure selected for disposal. The latter may depend upon the kind of industrial wastes or the kind of sewage sludge.

Since the refuse to be disposed of becomes increasingly more varied, determination of the waste types that might be encountered becomes an essential factor in planning. In other words, determination of what has to be eliminated is of primary importance, since once this point is elucidated unnecessary steps or detours may be avoided. Consequently, it seems unreasonable to avail ourselves of those indiscriminately used weapons — ideologies, personal and party prestige, politics in general, etc. — when approaching the task of devising and planning refuse disposal in the long run. Sober judgment and objective counsel must predominate here.

The procedure of disposal may readily suggest itself once the materials to be removed have been determined. Although generalizations in this respect are dangerous and should be avoided, it seems safe to state that, whenever regular dumping cannot be adopted (owing to hydroeconomy or other factors), refuse disposal will primarily consist in burning or ashing, according to the type of refuse; because whatever might be compostable can be burned, but not vice versa. Hence, if for example a significant part of the refuse consists of non-compostable industrial waste the latter will be decisive in the selection of disposal procedures, not the domestic refuse (which can be either composted or incinerated).

However, the processing and disposal procedures are, in turn, determined by two factors: the type of refuse, as already mentioned, and the quantity of the respective types. At this point it should be emphasized that the quantities can only be roughly estimated, especially those handled by communal plants, because weighing (weight being the only reliable unit) of all types of refuse is out of question (time and labour expenses prevent it), and also because with the changing components of the refuse an accurate estimation at present will be useless in a few years time, when the new installations will start operating.

Therefore, no undue emphasis should be put on quantitative examinations. It may be said by way of simplification that such an examination as, for example, the well-known weekly weighing of all types of refuse dumped has actually the value of revealing whether the quantities of refuse in the investigated region deviate significantly from the average range computed from the results obtained by communities that weigh the refuse regularly. If a significant deviation is revealed, it may be concluded that either the examination was not accurately carried out, or that the intake of refuse from industrial or other sectors was exceedingly high, or exceptionally low. The weight of domestic refuse per inhabitant per year in a geographically small area normally shows insignificant deviations, if the measurements are accurately performed and the results correctly interpreted. Great deviations from well-founded mean values are therefore not reliable unless they are plausibly explained. If reference data on quantities are required in connection with further planning, the determinations should be carried out accurately and extensively. As to the future, appropriate estimation remains the only possibility. In order to achieve reliable data for accurate planning and dimensions of refuse-disposal plants the amounts of industrial refuse and similar waste sources must be accurately ascertained beforehand, unlike those of domestic refuse and the wastes removed by the municipal authorities, because no aproximate or comparative data of industrial wastes are available. Determination of quantities requires at this point close cooperation with the respective factories and workshops, since they are in a position to supply the exact values of both present and future amounts. Unfortunately, we know from past experience that only a minority of the enterprises are ready to cooperate in this respect. Without trying to analyse the reasons, we should point out that time and again, with an almost uncanny regularity, the data supplied proved misleading, and inevitably resulted in refuse-disposal plants too small to cope with the amounts of refuse discharged by the enterprises concerned. When the disposal works planned according to the estimates received started to operate, it was found that the industrial effluents greatly exceeded the estimates previously supplied. Bearing in mind these sad experiences, the data obtained through these channels should be very cautiously handled in order to avoid similar pitfalls. The gentlemen responsible for the respective enterprises should realize that it is a matter of serious consequence whether a disposal plant attains its full-load capacity after a period of 15 years, or whether it is overloaded after only 5 years. Hence, quantitative estimations should be carefully examined at this point, irrespective of the estimations supplied by the enterprises.

Even more somber than the aspect of quantitative determinations seems to be that of refuse composition. Those engaged in qualitative analyses of refuse know that it is practically impossible to obtain a representative average from the caloric determinations of say, 100 examples, each of a few grams of dry matter, withdrawn from about 20,000 t/year. The position of refuse analyses as regards the type, water content, decomposable and resistant organic substances, etc., is not much better and, moreover, these analyses are expensive.

Although refuse analyses are doubtlessly valuable from the scientific aspect and are instrumental in obtaining estimates, it is questionable whether they are actually practical. There are examples from which we learn that to rely upon such analyses, or eventually to erect plants on the basis of the results obtained may have very unpleasant consequences.

Proceeding from the principle that domestic refuse can be either burned or composted, and that the type of industry in a given town or region readily indicates which of the two disposal methods should be adopted, there seems little scope for analyses of composition which inevitably infer sorting, shredding, screening, laboratory tests, etc. If, for the sake of peace of mind, it is decided to proceed with the analysis, it should be clear that sporadic analyses are of no value, while more thorough examinations, i. e., repeat analyses of larger quantities involve high expenses without yielding decisive results.

The size of the works required is determined from the quantities ascertained and types of refuse expected. The smallest unit of the processing plant is determined by the smallest dimension at which it runs efficiently. In this way it can be immediately established whether a certain community is in a position to run the plant at an economically sound load. This infers that in certain cases the solution should be sought in a regional not a local plant.

If this is the case, it should not be taken for granted that neighboring communities which also encounter difficulties in refuse disposal, and which must look for another process, will participate in the given conditions, or will at least transport the refuse at cost price once the plant is built and ready to operate. What actually happens, as known from experience, is that neighboring communities seldom cooperate in such situations, and the builder must be prepared to be left alone with his plant which will be too large for him. However, predictable inadequate utilization of the available capacity with the inherent high running costs is not the only danger incurred by such a precipitate independent move. If the other communities do finally join the scheme and supply their refuse according to plan, it may well happen that the refuse supplied requires a different type of processing and must be rejected, or the plant will be exposed to trouble and premature wear.

If the smallest waste-disposal unit is determined by the minimum dimensions of certain elements, as earlier stated, it does not necessarily imply that the smallest unit is always equivalent with the smallest possible plant. This is true provided there are either adequate sites available where all the refuse can be diverted in sanitary fill while the plant is idle in case of breakdown, or if the refuse can be temporarily taken to another plant. The alternative dumps must comply with all the requirements imposed on dumping sites, among others they must be authorized by the respective water-supervision authority. If neither an alternative dump nor an alternative plant is available, i.e., if disposal has to be provided, at any price, then the smallest plant should consist of two units. Even in this case, a solution at the regional level should be looked for in order to achieve, in the given conditions, the highest economic efficiency.

It follows from the above said that:

1. The collection area of a refuse disposal plant must be determined at an early stage.
2. If a regional plant is envisaged a survey of the refuse types should be carried out in each community.
3. The extent of participation required should also be clarified in each case.

In this connection let us mention two essential aspects which interfere not only with the creation of a closed region in the sense outlined above, but, also with the reclamation of larger areas in general. In addition to other problems, precisely these two aspects seem essential and their elucidation might assist in finding a general solution.

Small communities are frequently known to possess some vacant plots that might be used by the inhabitants as dumping sites for many years to come. In such cases we encounter, as a rule, an understandable lack of inclination to participate in a disposal plant within the framework of a cooperative, or similar basis, since it would demand considerably larger expenses than the current procedure.

Though obviously justified, these considerations should not be allowed to interfere with large-scale reclamation projects that might be deferred and obstructed on account of small usable dumping grounds. However, if this line of reasoning is to meet with understanding, the concept of a large-scale reclamation project should be clearly expounded, as well as the range over which such a project is expected to be in force.

Refuse disposal, as earlier defined, must aim at harmlessly removing the refuse of a region, at changing it in such a manner that danger-free dumping is possible at any time and practically anywhere, or at reducing its volume to such an extent that the existing dumping sites would last for a long time to come. The dumping sites still left should not give rise to objections (not even from the esthetic aspect). The site allocated for a refuse-disposal plant should be large enough to allow the building of a plant, the size of which will prove economically sound.

Apart from the fact that small dumps only very rarely, if at all, resemble a sanitary fill – and they cannot do so because of the cost involved – and that it is precisely these many small open dumps that should disappear, it would be against the principle of a large-scale reclamation project to allow individual small dumps to continue to exist. The waste-disposal area should include the dumps of residual material, wastes that cannot be processed, etc. All necessary measures for keeping the area clean should be controllable and, if possible, directed from one center. Therefore, if refuse disposal is planned for an extensive area, and that would be sensible, scattered unsightly dumps must disappear from the landscape, leaving only one controlled deposit of the remnants, or of the material that cannot be processed, and this, not only on paper but in actual practice.

Another important aspect is that no technique of refuse disposal can operate without dumps. Thus, building rubble, excavated material, street refuse, quarry dust, fuel waste will always remain to be dumped, i.e., such types of waste that need not be converted or processed in order to be safely dumped, and cannot be disposed of by composting, ashing, or burning. Furthermore, it is quite probable that occasionally wastes from processing plants, especially fly ash, slag and compost will have to be dumped. Therefore, if a suitable terrain of adequate size is available in the vicinity of the processing plant, the need for reserve space in the plant area or of incinerators at the composting plants should be taken into consideration.

In regional planning such terrains are not only desirable, but indispensable. This is another instance in which the interests of a community should be subordinate to higher interests, even though each case requires special examination. It should be emphasized, that in the long run the respective community will have to join in a regional waste disposal scheme, in any case. Therefore it may prove more advantageous to be among the founders of the project and not to try to push in later under correspondingly worse conditions. It is common practice to reward stragglers with a particularly high share of the costs.

Here I may be allowed to add a few brief remarks on sanitary fill as a form of waste disposal. It seems as if this word had been eliminated from the vocabulary of rather wide circles, or at least, was not taken seriously anymore. On the other hand, the alarm is sounded everywhere that the space for dumping is definitely coming to an end! And this may happen to be true for those areas where free terrains are altogether very rare, or where the hydroeconomy office forbids refuse dumping. Nevertheless, thorough investigations frequently reveal that dumping spaces are still available, though not utilized.

In fact, the often encountered opposition to the utilization of land reserves as dumping sites stems from other sources than those mentioned earlier. On closer examination this opposition proves to be unfounded and based on ignorance of the procedure. It is worthwhile mentioning here that a sanitary fill was successfully initiated and operated in the center of a pretentious residential area of a large German town and that no complaints were voiced throughout the time of its utilization. Further, it should be stressed that so far this method of waste disposal has certainly not been exhausted as a means of landscaping. Thus, for example, hills that were raised by landfill in flatland and subsequently afforested provide now favorite spots for trips and outings.

It is important to organize the dumping really well, to take care that restoration follows as soon as possible, and to convince the authorities in charge of dumping permits that the final product will have nothing in common with the usual ill-famed heaps. It should also be borne in mind that dumping will probably always remain the cheapest form of waste disposal. Hence, before any expensive disposal plants are planned, all the possibilities in this direction should be exhausted, not to mention the landscaping aspect. Now and then, expert advice would probably not be amiss in the search for suitable dumping grounds.

The second difficulty that constantly obstructs large-scale planning is the eccentricity of many communities which adopt the point of view that it is better to own a plant or a bad dumping ground than to join a cooperative that might even significantly reduce expenses. We shall not enter here into an analysis of the factors responsible for this attitude, nor will we discuss the political, personal, parochial or other considerations that lead to it; these are of no interest. For the sake of those that ultimately pay for the waste disposal, no other solution but the most economical should be sought. To this end sensible planning is required, and this should be undertaken on the basis of technical understanding, sober calculation and extensive expert knowledge supplemented, if necessary, by objective advice. Any approach liable to interfere with the professional work should be disregarded.

Once the most economical solution has been arrived at on the basis of thorough studies and it has been established that a refuse disposal plant is unavoidable, the building and running costs will be calculated and the figures shown will seem shockingly large, although nothing superfluous will have been included in the plan. The town councillor is then easily tempted to call for the aid of the State's purse! However, upon mature consideration the cost of waste disposal will be found to be rather modest, as shown by a brief and greatly simplified calculation.

Let us assume that the total annual expenditure of a refuse-disposal plant amounts to 40.- DM per ton; and further, that the yearly quota per inhabitant is 240 kg; and the bulk volume unit of domestic refuse, measured in the refuse bin of 110 liters capacity, is 230 kg/m^3. Accordingly, the contribution required per inhabitant per year amounts to approximately DM 9.60. Assuming that the refuse bin is emptied, on an average, when containing 95 l, i.e., about 21 kg, and that about 5 kg refuse accrue weekly per inhabitant, the latter will have to cover 25% of the cost of removal if the bins are emptied once a week. Since the total cost to be covered is DM 40 per ton, i.e., 4 pfg. per kilogram, each inhabitant would be taxed approximately 20 pfg per week, and the bin charge would have to be raised by about DM 44 per year.

This calculation is aimed at showing the order of magnitude. Thus it is evident that even a considerable increase of the bin charge is reduced to a practically negligible sum of a few pfennigs per inhabitant per week, provided the costs are converted into the actual service, i.e., weekly emptying of the bins. Hence, it may be concluded that, occasionally, it is advisable and correct to present the inhabitants with a detailed and explanatory account of the total costs.

In view of this situation, it seems questionable whether so much fuss should be made about refuse disposal, and especially whether the State's purse should be open for building and operating such plants. It seems much more justified to inquire whether the State would not best assist the communities by giving them the freedom of finding independently the appropriate advice.

Competent advice should have much more weight in preliminary and final planning of waste disposal. This is a task that should be untertaken at a national level. The head of a municipal office is evidently not in a position to engage in his own office in all the preliminary investigations and planning required. For that reason engineering firms are frequently commissioned to carry out this work (we disregard here large towns that have the necessary facilities in their own institutions). A State Advisory Board should be available to communities for the evaluation and the interpretation of the reports or preliminary reports submitted by the firms, unless the board has already been in touch with the community or the engineering firm. A State Advisory Board is also eminently suitable for the evaluation and appraisal of projects, preliminary projects and tenders. This is justified, especially because of the following two factors:

1. The advisory authority must be independent, i.e., must be free to state its opinion unequivocally, whether in favor or against a certain project or offer. A municipal or communal employee is more often than not compelled to give due consideration to the political viewpoint of the council, or of the governing political party, and an engineering firm must take into account the interests of other customers, and refrain from giving advice that would be in sharp contradiction to the interests of the latter. However, as repeatedly stated before, in the field of refuse-disposal economics we should be concerned only with finding objectively the best solution.

2. The advisory authority must not treat the specific aspects as a sideline; colleagues from the respective fields should be consulted when border problems or wider questions arise, and each member of such a team must work full-time in his field. This is the only way of concentrating in one point the widest possible expert knowledge. However, only a State authority can afford to employ a team of experts encompassing all aspects in the field of waste disposal, and make them available as advisers (as mentioned in 1). In this connection it should be emphasized again that the question is not only that of disposing of those waste groups which are dealt with by the municipal cleaning services. Everything that accrues as waste in the respective settlement should be included and taken into account. A municipal employee cannot be expected to cope with all the aspects and problems arising in this connection and to solve them in the best possible way.

Summary

Essential aspects of refuse disposal have been briefly expounded. Sanitary fill was shown to provide now, as before, an efficient tool in the economy of refuse disposal. If a thorough and accurate investigation shows that technical processing is indicated, before deciding upon the procedure and capacity of the plant several essential points must be clarified. In doing so only pertinent factors should be taken into account. By means of a simple calculation it is shown that refuse-disposal is not so expensive as to require financial help from the State authorities. Conversely, a State Advisory Board, properly staffed and adequately equipped, would achieve substantial results.

Bibliography

Braun, R. Die Faktoren, die bei der Planung einer Anlage zur Beseitigung fester Siedlungsabfalle berücksichtigt werden müssen (Factors that Have to Be Taken into Account in Planning a Disposal Plant for Solid Domestic Refuse). – Paper read at the 2nd Congress of the International Society for Waste Research IAM in Essen. 1962.

Braun, R. Neue technische Entwicklungen auf dem Gebiet der Abfallbeseitigung in der Schweiz (New Technical Developments Concerning Waste Disposal in Switzerland). – Paper read on the occasion of the 19th Plenary Session of VSA on 22 March, 1963, in Zurich.

Jaag, O. and P. Keller. Die Planung einer regionalen Anlage zur Beseitigung von Siedlungsabfällen, dargestellt am Beispiel der Region Zurcher Oberland (Schweiz) (The Planning of a Regional Plant for Domestic Waste Disposal, as Exemplified by the Zürcher Oberland Region (Switzerland)). – Stuttgarter Berichte zur Siedlungsabfallwirtschaft No. 3. 1961.

Kumpf, Maas, Straub. Mull- und Abfallbeseitigung (Refuse and Waste Disposal). – Handbook on Collection, Disposal and Utilization of Waste from Households, Communities and Industry. – Erich Schmidt, Berlin. Appearing since 1964.

VSA, Verband Schweizericher Abwasserfachleute. Wegleitung fur die Beseitigung von Industrieabfallen (Instructions for the Disposal of Industrial Waste). – Richtlinienverlag Aarau, Edition 1964.

Wuhrmann, K. Untersuchung uber die Bedeutung der Anlagegrösse bei der Abfallbeseitigung durch Verbrennung oder Kompostierung in ländlichen Gebieten (Investigations on the Importance of Plant Size in Waste Disposal by incineration or Composting in Rural Areas). – Informationsblatt der Intern. Arbeitsgemeinschaft für Mullforschung No. 20.

CHANGES IN APPLICATION OF REFUSE COMPOST IN THE NETHERLANDS SINCE 1959

By Ir. B. Teensma, Amsterdam

Since 1959, Foundation "Compost" has regularly ascertained for what purposes compost produced in the Netherlands is used. Comparison of the corresponding data for 1959 and 1963 shows that great changes have taken place in the utilization of compost during those five years, out of which 1959 and 1963 are useful for comparison. In those two years, known quantities of compost and their use were almost the same, although compost production differed. In 1959, there were 11 composting plants which produced 194,331 tons of compost; in 1963, composting plants numbered 15 and produced 205,554 tons, but the use of only 193,863 tons is known.

Although in 1963 four additional composting plants were in operation as compared with 1959, and despite an increased urban population leading to increased production of refuse, the compost quantities from 1959 – 1963 increased only by 6% – considerably below the expected increase of 30% for this period. The comparatively small rise in compost production resulted from changes in the composition of refuse which led to an increase in materials unsuitable for composting. In addition, several composting plants were overloaded because of increased intake of such refuse with a subsequent negative effect on the compost yield.

The following table compares compost utilization in tons between 1959 and 1963 in the fields of application which are usual in Holland. The last column lists the 1963 application as a percentage of that of 1959.

In the block diagram (see p. 76) these relations are illustrated graphically.

We want to discuss briefly the changes that have taken place since 1959.

Field of application	1959 t	1963* t	1963 in % of 1959
Plowland	68,664	32,338	47.1
Mixed stable dung	17,752	8,221	46.3
Pastures and meadows	7,678	4,435	57.8
Chicken houses and pig sties	3,777	875	23.2
Forestry	6,066	955	15.7
Vegetable cultivation (compost)	25,055	24,544	98.0
" " (hothouse manure)	9,714	23,046	237.2
Flower-bulb cultivation	7,316	29,048	397.0
Fruit growing	4,988	9,016	180.8
Parks, sports grounds	43,321	61,385	141.7
Total	194,331	193,863	99.8

* In the tables published in this article, the quantity of compost (11,692 tons) produced in 1963, of which utilization is not known, is disregarded.

1. Plowland

By 1963 the use of compost on plowland decreased by more than half (52.9%) as compared with 1959. This phenomenon has three causes.

a) Compost for plowland is the cheapest quality compost produced, and the demand for better qualities (which are also more expensive) increased considerably after 1959. Most composting plants which were able to do so, therefore, changed over to producing mainly these more expensive and financially more advantageous qualities (needed for sports grounds, and vegetable and flower-bulb cultivation).

b) The largest composting plant in the Netherlands (Wijster) produces almost exclusively agricultural quality compost. However, it is just this plant which is overloaded, and the compost yield consequently decreased by about 30%.

c) The third cause is the bad results achieved in agriculture in recent years. Compost fertilization with 30 tons/ha costs about 300.— Hfl/ha, including transport and spreading. With current prices of agricultural produce, the farmers need cash for buying machinery because manpower shortage requires steadily increased mechanization of the farms.

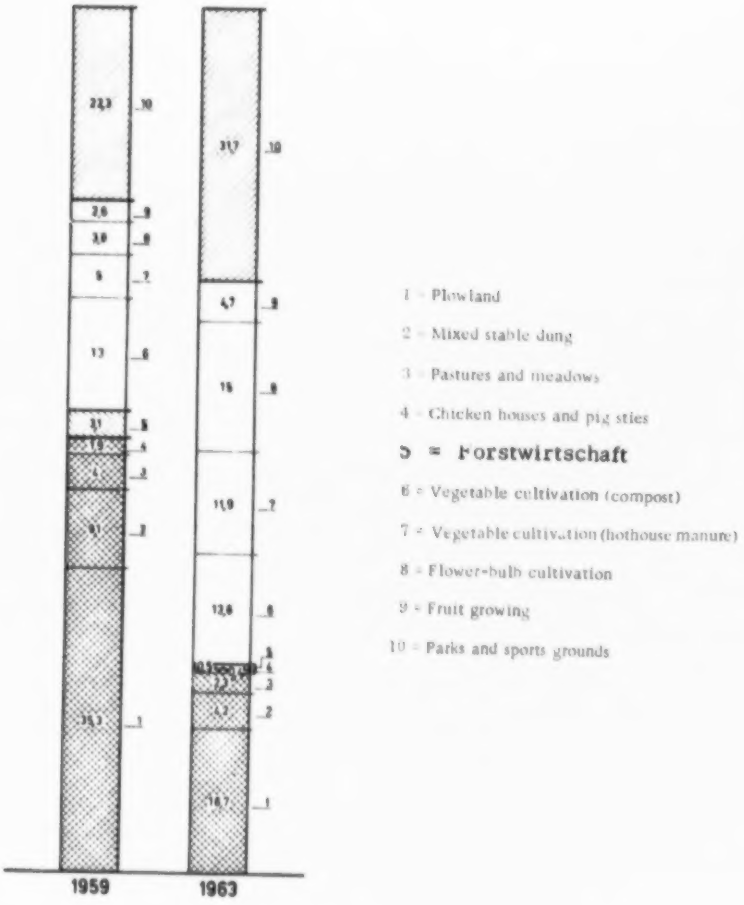
2. Mixed Stable Dung

This mixture is used in mixed enterprises of plowland and pastures with the aim of obtaining fermented, high quality manure. The product (mixture of stable dung and compost) is used almost exclusively on plowland. A reduction by more than one half of this kind of application is due to the same causes as given in point 1.

In addition, many mixed farms (and also pastoral enterprises) changed over to preparing liquid manure, which saves a great deal of labor but offers no possibility of using compost.

3. Pastures and Meadows

The use of compost on pasture land decreased by 42% since 1959; this corresponds to the decrease listed under plowland and mixed dung. The causes are also similar.



In addition, the number of cattle per unit area in mixed and pastoral enterprises increased considerably in recent years, with a consequently higher production of organic manure.

4. Chicken Houses and Pig Sties

For these purposes, too, the use of refuse compost has decreased considerably (76.8%) since 1959. The great expectations, which originally accompanied the use of refuse compost for litter, were not met. Compared with peat moss, for instance, compost absorbs too little moisture, and in badly ventilated hen houses it becomes too moist in winter. Regular turning needed to keep it dry requires too much labor.

The use of refuse compost in pig sties as medicine for young pigs against anemia has increased, but this market is small.

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NOTE. Item 5 of the legend to the illustration appearing on page 76 should read:

5 = Forestry

5. Forestry

As a consumer of compost, the forestry industry is of very little importance (in 1963 it used only 0.5% of the total compost output). The sale of Dutch forest litter to Belgium (for azalea cultivation) has been almost entirely suspended on recommendation of the government forest authority, which found that lumber production decreased considerably after sale of litter. Forest litter (especially in coniferous forests) contains many fine roots which do not regenerate when the litter is removed, even when it is replaced by compost, as was often done formerly.

For fertilization in forestry, compost is used very little now as it seems financially not worthwhile.

6.
7. Vegetable Cultivation (Compost and Hothouse Manure)

Refuse compost and refuse hothouse manure can be treated together because their use is similar. These two products are used mainly in vegetable cultivation in hothouses, mostly in the Westland (between den Haag, Hoek van Holland, and Rotterdam) and in the Bommelerwaard (north of Hertogenbosch). In the Westland, compost is used largely for growing lettuce and tomatoes, and hothouse manure for cucumbers and melons, whereas in the Bommelerwaard refuse-peat compost (a mixture of refuse compost and peat) is used specially to make the soil "ripe for vegetable growing" (Bommelerwaard is a new gardening area with tomatoes and stawberries as the main crops). In recent years, much refuse-peat compost has been used in chicory cultivation. Since 1959 the consumption of compost and hothouse manure has increased by 36.9%, compost consumption remaining relatively constant. On the other hand, the use of hothouse manure increased by 137.2%, due to the considerable increase in cucumber growing in recent years. In 1963 it was impossible to satisfy the vegetable growers' demand for compost and hothouse manure.

8. Flower-Bulb Cultivation

Since 1959 the consumption of compost in flower-bulb cultivation in the Haarlem and Leiden areas has increased by almost 300%. Compost is needed for both fertilization and soil covering as protection against wind erosion. The increase has slowed down greatly in recent years only because there is not enough compost available. In this connection, it is very regrettable that the city of Leiden decided to build a waste incineration plant.

9. Fruit Growing

In fruit growing, too, compost consumption has increased (by about 80%). Lately much refuse-peat compost has been used for fertilizing planting holes in young orchards. Orchards as compost users are rather inconsistent, however. The year 1961 was very good financially for fruit growers, and compost consumption also showed a marked peak, but this was followed by a renewed decrease in compost consumption by fruit growers.

10. Parks and Sports Grounds

The so-called recreation sector is now the largest compost consumer, having used almost a third (29.9%) of all the compost produced in the Netherlands in 1963. Since 1959 the consumption has increased by 41.7%, and is continuing to increase. For top fertilization of lawns and sports grounds, the production of select composts (a very fine product) has been greatly increased as both agricultural and horticultural fertilizers are used for establishing lawns and sports grounds.

Summary

The different fields in which compost is used can be grouped as follows:
A. Agriculture (plowlands, mixed stable dung, pastures and meadows, chicken houses and pig sties)
B. Forestry
C. Horticulture (vegetable growing, flower-bulb cultivation, fruit growing)
D. Recreation Areas (parks, sports grounds, road planting, private gardens, etc.)

As compared with 1959 we obtain the following picture for 1963:

	1963*		1959		1963 in Relation to 1959	
	Tons	%	Tons	%	Tons	%
Agriculture	45,869	23.7	97,871	50.3	-52,002	-53.1
Forestry	955	0.5	6,066	3.1	- 5,111	-84.3
Horticulture	85,654	44.2	47,073	24.3	+38,581	+82.0
Recreation areas	61,385	31.6	43,321	22.3	+18,064	+41.7
Total	193,863	100.0	194,331	100.0	- 468	- 0.2

This table shows that in 1963 horticulture consumed most of the compost. Within five years, consumption of compost in this group increased by 82%.

Within this group, the greatest increase in use was in hothouse compost for vegetable growing (cucumbers) and for cultivating flower bulbs.

The second place is taken by recreation areas with an increase of 41.7% since 1959.

Agriculture has dropped from first to third place since 1959, with a decrease in compost consumption of 59.5%.

Finally, it appears that forestry, whose compost consumption was still of some importance in 1959, by 1963 had practically ceased to be a consumer of any consequence.

DISCUSSION

Contribution by Dipl. Ing. K. Wuhrmann, Zurich

In No. 22 of the IAM-Mitteilungen Mr. V. Stahlschmidt mainly discussed the statement that the figures as assumed in my study dealing with the size of plants, cannot be used for determining the investment and operating costs. It seems, however, that he overlooked the purpose of the exposition, i.e., to correlate the operating and transport costs, so as to assess the advantages of forming groups. The operating costs – expressly given approximately – are given in values that can be roughly calculated as well as determined from actual practice. If Mr. Stahlschmidt objects to the "extremely sharply drawn curves", I want to emphasize again that these are two systematically comprehensive types of plant consturction, between which lie the most frequently used variants. Therefore, if I speak, e.g., of a plant size of 6,000 tons per year and mention the range of operating costs of 35 to 54 Fr. per ton or 35% of the maximum value, it certainly cannot be called "spurious accuracy". Diagram 3 shows that this large margin has been retained for practically all plant sizes, and it is perfectly usable for assessing the efficiency of different regional sizes. After all, it was found, as explained on page 11, that there is not much incentive in partial solutions even at about 40,000 inhabitants, to increase the size of the region; whereas for well founded plants even 100,000 inhabitants do not represent the upper limit under my assumptions. Obviously, there are many useful solutions in between.

In point 3 Mr. Stahlschmidt criticizes the course of my curves, assuming that at all times they concern the same plant under a different load. Yet Diagram 1 expressly points out that the values refer to full load, i.e., under the assumption of a plant suitable for any size of region and working to full capacity. This assumption is an indispensable condition for a general investigation, since the system or plant sizes required for a certain product should not be prejudged. Of course, the costs are more unfavorable in case of partial utilization, but this is not of decisive importance for the content of Diagram 3. Besides, this also applies to the assumed transport costs, which have been determined more accurately since 1963, the time when this paper originated.

Furthermore, Mr. Stahlschmidt mentions in connection with the regions Zurcher Oberland and right and left shores of the Zurich Lake, that comprehensive studies exist and that apparently comparable regions have no common criteria as regards investigations into their economic efficiency. On the contrary, it seems to me that precisely these studies made us abandon the previously widespread theory according to which composting alone is an economical solution even for small communities. Furthermore, it was found, though partly with operating costs taken too low, that 100,000 to 150,000 inhabitants (in these cases with higher density of habitation than assumed in my study) are a desirable size, but it was not explained that an even larger region would be more unfavorable.

Finally, it should be emphasized how desirable the publication of such investigations is. It is a regrettable fact that too few data are published concerning the operating costs of waste disposal plants, even by firms which build such plants. For instance, in the discussion by Mr. Stahlschmidt there is not one figure that in his opinion could be substituted for my estimate.

Contribution by Prof. Dr. O. Jaag, Director of the Eidg. Anstalt fur Wasserversorgung, Abwasserreinigung und Gewasserschutz an der ETH, Zurich [National Institute of Water Supply, Sewage Treatment and Water Protection at the Technical University of Zurich]; President of the Internationale Arbeitsgemeinschaft fur Mullforschung [International Group for waste Research]:

"Announcement of the Closure of Refuse Composting Plants in Switzerland, published in the "Kronberger Anzeiger" (Taunus) of 5 February, 1965."

We have been informed from different sides in Switzerland and Germany that the "Kronberger Anzeiger" of 5 February, 1965, published a report according to which Switzerland would in future not approve or build any waste composting plants because it was found that they were not up-to-date. Furthermore, the aforementioned newspaper report stated that the composting plant of Kusnacht in the canton of Zurich would have to be demolished because it constitutes a nuisance to the neighboring city of Zurich on account of the smell.

Since this report is a complete fabrication and is utterly unsubstantiated, we feel obliged to state officially the following facts:

At present there are nine waste incineration plants in operation in Switzerland; of these, four are large-scale plants with heat utilization in the cities of Zurich, Basel, Berne, and Lausanne, and five are small-scale plants (so-called ashing plants without heat utilization). Two other large plants are in the construction stage.

In addition, there are eleven waste composting plants in operation in Switzerland at present. These are mostly regional plants connected with a great number of larger and smaller communities. For example, the plant of the Werdenberg-Liechtenstein Region in Buchs (Canton St. Gallen) is connected to 19 communities of the Canton of St. Gallen and the neighboring Principality of Liechtenstein. This example shows that not only cantonal boundaries, but even state boundaries are no obstacle in efficient planning of waste disposal. In the region of the Zurcher Unterland, 23 communities united in processing their waste in the composting plant of Hinwill. The city of Olten has just finished building a large composting plant which in the future will process the waste from 12 communities of the cantons of Solothurn and Aargau. A regional composting plant is being built in the area of the right shore of the Zurich Lake, to which 13 communities will be joined. The same is happening on the left shore of the Zurich Lake. Quite a number of other regional composting plants are at present in the design stage.

This fact alone ought to show that the aforementioned report is incorrect. In Switzerland there is no tendency at all to prohibiting composting plants; on the contrary, responsible circles are convinced that composting is an efficient form of treating domestic refuse and sewage sludge in small and medium communities, as opposed to pure incineration plants in which the processing of sewage sludge has so far not been met in a technically and economically satisfactory manner.

The closing of the composting plant in Kusnacht is also out of the question. For that there is no factual reason; it is not known in Küsnacht or in the neighboring communities, and even less in Zurich, that there is any nuisance on account of smell. On the contrary: a few years ago the plant was enlarged and its capacity considerably increased.

We regret that the general public was misled by such tendencious fabrications.

ANNOUNCEMENTS OF THE SECRETARIAT

New National Groups of IAM

We take pleasure in announcing that **Belgium** has decided to found an official national group of IAM. The chairman is Ms. E. Cox, Ingénieur Directeur of "Service Communal de Belgique" (Société coopérative intercommunale) in Brussels. Those in Belgium who are interested are asked to obtain the Information Bulletin from this institution, in the future.

In France there was until now a national group of IAM under the chairmanship of Ms. Dir. Georges Dobrouchkess, Paris, who resigned however, several months ago. The presidium of IAM expresses its thanks to Mr. Dobrouchkess for his valuable cooperation during many years. In the meantime, a successful effort was made to found a new national group in France. The Chairman is Mr. P. Clairgeon, President of the "Association Générale des Hygiénistes et Techniciens Municipaux" (A.G.H.T.M.). Also those interested in France are asked to apply to this institution.

We express our appreciation of the successful efforts by the leading gentlemen in founding the national groups in Belgium and France.

BOOK REVIEW

Research Report No. 1251 Nordrhein-Westfalen, Dr. Ing. Werner Noack, Emschergenossenschaft, Essen. "Sludge Treatment in Municipal Sewage Disposal Plants with Special Regard to Sludge Gassification" (Die Schlammbehandlung in stadtischen Klaranlagen unter besonderer Berucksichtigung der Schlammvergasung).

Koln und Opladen: Westdeutscher Verlag 1964, 84 pages, 25 illustrations, 10 tables. DM 43. -

Sludge forming in sewage treatment must be handled in such a way that no unfavorable effects occur. The hitherto usual process of decomposition and natural dewatering in sludge beds can no longer be applied everywhere. Besides, biological purification requires much more power than mechanical purification.

Sludge gassification represents a combination of direct sludge treatment obviating decomposition and the power supply required by the entire purification plant. The special advantages of the process are in particular: elimination of bad smell and air pollution, removal of all organic substances and simultaneous destruction of bacteria contained in the sludge, independence of toxic substances in the sludge, small space requirements, and recovery of the energy contained in the sludge.

Experiments were made with various types of sludge and with the parallel- and counter-flow methods. Subsequently, the costs of decomposition and gassification are compared.

Sludge gassification is another process available for treatment of sewage sludge. Comprehensive numerical data simplify work in checking the process for different applications.

LITERATURE RECEIVED BY THE SECRETARIAT

Albinus, G. Verbrennung von Abfällen in kleinen Anlagen (Waste Incineration in Small Plants). – Der Städtetag, Issue 10. 1964.

Albinus, G. Keine Belästigung durch Müll. Emissionsminderung bei kleinen Abfallverbrennungsanlagen (No Nuisance from Refuse. Reduced Emission in Small Waste Incineration Plants). – VDI-Nachrichten No. 14, 7 April 1965, Düsseldorf. 1965.

Aust, A. Waste Treatment in Today's Urban Era. – Compost Science, Autumn-Winter, Vol. 5, No. 3. 1965.

Babel, U. Dunnschnittuntersuchungen über den Abbau lignifizierter Gewebe im Boden (Investigations of Microsections Concerning the Decomposition of Lignified Tissues in the Soil). – Soil Micromorphology, Elsevier Publishing Company, Amsterdam. 1964.

Bopp, R. Eine neue Maschine zur Zerkleinerung von Sperrmull (A New Machine for Comminuting Bulky Refuse). – Schweiz. Bauzeitung, Issue 6, 83rd year of publ., Zurich. 1965.

Bopp, R. Abfallbeseitigung, ein dringendes Problem auch fur uns (Waste Disposal, an Urgent Problem for Us Too). – Luzerner Tagblatt, No. 35, 12 Feb. 1965.

Borchert, F. Gutachten über die Sammlung, Aufbereitung und Beseitigung von Sperrmull, erstattet nach dem Stand vom 31. Dezember 1963 im Auftrag des Bundesministeriums für Gesundheitswesen (Expertise on the Collection, Processing, and Disposal of Bulky Refuse, based on conditions as at 31 December.1963, on Instructions of the Federal Ministry of Health). – Schriftenreihe des Deutschen Arbeitskreises Wasserforschung e.V., DAO, Erich Schmidt-Verlag Berlin. 1964.

Braun, R. Beseitigung flussiger und fester Abfalle aus Metzgereien und Schlachthofen, inkl. Kadaververnichtung (Disposal of Liquid and Solid Waste from Butchers Shops and Slaughterhouses, Including Carcass Destruction). – Schweiz. Archiv für Tierheilkunde, Volume 106, Issue 7, Zurich. 1964.

Braun, R. Die Beseitigung fester Abfallstoffe (Disposal of Solid Waste). – Chemische Rundschau, No. 25, 3.12.1964, Solothurn. 1964.

Braun, R. Regionale Anlagen fur die Beseitigung von nicht faulnisfahigen Industrieabfallen (Regional Plants for the Disposal of Nondigestible Industrial Waste). – Schweizer Journal, 31st year of publ., No. 2. 1965.

Carlyle, R. E. and S. Brotonegoro. Composting Refuse in Indonesia. – Compost Science, Spring, Vol. 5, No. 1. 1964.

Caspari, F. Capillary Drying of Mixtures of City Refuse and Sewage Sludge. – Compost Science, Summer, Vol. 5, No. 2. 1964.

Caspari, F. Ein neuer Weg zur Aufbereitung und Verwertung von Siedlungsabfallen (A New Method of Processing and Utilizing Municipal Waste). – Kommunalwirtschaft, Issue 4, Dusseldorf. 1964.

Davies, A. G. An Appraisal of Composting in England. – Compost Science, Summer, Vol. 5, No. 2. 1964.

Davies, A. G. Points to Consider in Refuse Disposal. – Compost Science, Autumn-Winter, Vol. 5, No. 3. 1965.

Davies, A. G. Bundestagung des VKF in Munchen (Congress of the VKF in Munich). – Der Städtetag, Issue 12. 1964.

Donhue, J. R. The Development of Compost Plant Design. – Public Cleaning, Vol. LV, No. 4, London. 1965.

Druart et Catin. Syndicat intercommunal d'équipement de la région de Chambéry, Station de Traitement des ordures ménagères de Bissy. – Techniques et Sciences Municipales, No. 2, Paris. 1965.

Dupont, G. La désodorisation des gaz de fermentation des ordures ménagères dans les usines de compostage. – Bulletin de l'A.R.P.E.A., No. 6, Nov. 1964, Geneva. 1964.

Erbel, A. Müllgefasse aus Kunststoff (Plastic Refuse Bins). – Der Stadtetag, Issue 1. 1965.

Etherton, H. Oregon Farmers Save Money by Composting. – Compost Science, Spring, Vol. 5, No. 1. 1964.

Fischer, F. VIII. Internat. Kongress fur Stadtereinigung in Wien (Eighth International Congress on Town Cleaning in Vienna). – Der Stadtetag, Issue 8. 1964.

Etherton, H.-L. Oregon Farmers Save Money by Composting. – Compost Science Vol. 5, No. 2. 1964.

Fischer, H. Private Mullverbrennungsanlagen (Private Waste Incineration Plants). – Der Stadtetag, Issue 3. 1965.

Franz, M. Large-Scale Composting in the Soviet Union. – Compost Science, Summer, Vol. 5, No. 2. 1964.

Frechen, B. Mullkompostierung und Absatzgarantie (Composting of Refuse and Guarantee of Sales). – Kommunalwirtschaft, Issue 1, Dusseldorf. 1965.

Geering, J. Ueber den landwirtschaftlichen Nutzwert von Abfallstoffen nach Ergebnissen von Gefass- und Feldversuchen (The Value of Agricultural Use of Waste According to Results of Experiments in Containers and Fields). – Schweiz. landwirtschaftl. Forschung, Issue 3, Bern-Bumpliz. 1964.

Gentile, Ph. Resources for The Future and Industrial Conservation. – Compost Science, Spring, Vol. 5, No. 1. 1964.

Glathe, H., G. Farkasdi, G. Niese, A. v. Klopotek, and E. Ahrens. Beitrage zur Biologie des Brikollare-Verfahrens (Contributions to the Biology of the Brikollare Process). – Stadtehygiene, Issue 7. 1964.

Heescher, H. Bruckenkrane fur Mullverbrennungsanlagen (Traversing Overhead Cranes for Waste Incineration Plants). – Fordern und Heben, Feb. 1965, Wiesbaden. 1965.

Hindinger, L. Stand der Stadtreinigung in Munchen (State of Town Cleaning in Munich). – Der Stadtetag, Issue 10. 1964.

Horstmann, O. Gedanken zur Mullbeseitigung unter besonderer Berucksichtigung der Mullkompostierung (Reflections on Refuse Disposal with Special Regard to Composting). – Verband Kommunaler Fuhrparks- und Stadtreinigungsbetriebe, Frankfurt a. M. 1964.

Horstmann, O. Leistungs- und Kostenermittlung bei der Mullabfuhr (Investigations of Performance and Costs of Refuse Disposal). – Der Stadtetag, Issue 2. 1965.

Imhoff, K. and K. R. Imhoff. Die naturlichen Verfahren der Schlammentwasserung sind immer noch wirtschaftlich (The Natural Processes of Sludge Dewatering Are Still Economical). – Das Gas- und Wasserfach, Wasser-Abwasser, 105th year of publ., Issue 26. 1964.

Johnson, C. A. Liquid Handling Processes for Poultry Manure Utilization. – Compost Science, Autumn-Winter, Vol. 5, No. 3. 1965.

Jungst, G. Katalytische Nachverbrennung lastiger und schadlicher Abgase (Catalytic Secondary Combustion of Offensive and Deleterious Exhaust Gases). – VDI-Nachrichten of 9.12.1964, Dusseldorf. 1964.

Kachulle, C. Beitrag zur Planung von Anlagen für die Unschädlichmachung fester Siedlungsabfalle (Contribution to the Planning of Plants for Rendering Solid Municipal Wastes Innocuous). – Deutsche Architekten- und Ingenieur-Zeitschrift, 2nd year of publ., Issue 3. 1964.

Karnovsky, F. Zur Frage der gefahrlosen Beseitigung von industriellen Abwassern und Schlammen (On the Question of Safe Disposal of Industrial Sewage and Sludge). – Wasserversorgung und Abwassertechnik in Haus, Hof und Strasse, 15th year of publ., Issue 2, Verlag Pfriemer, Munchen. 1964.

Kaupert, W. INTAPUC-Kongress in Wien (INTAPUC Congress in Vienna). – Stadtehygiene, Issue 8. 1964.

Kaupert, W. Plastikgefasse für die Müllabfuhr (Plastic Bins for Refuse Collection). – Stadtehygiene, Issue 10. 1964.

Kaupert, W. Grunde für Kostenunterschiede in der Stadtreinigung (Causes of Different Costs in Town Cleaning). – Der Stadtetag, Issue 10. 1964.

Kaupert, W. Mull in kleinen und grossen Oefen (Waste in Small and Large Furnaces). – VDI-Nachrichten No. 9 of 26.2.1964.

Kaupert, W. Moderne Fahrzeuge und Gerate der Mullabfuhrbetriebe (Modern Vehicles and Devices in Refuse Collection Enterprises). – Der Stadtetag, Issue 8. 1964.

Keegan, P. Tenafly, N. J. Welcome City Leaves. – Compost Science, Autumn-Winter, Vol. 5, No. 3. 1965.

Kehse, R. Der neue Siebwagen fur die Mietenkompostierung (The New Screen Truck for Windrow Composting). – Die ortliche Versorgungs-Wirtschaft, Issue 1, Organ des Institutes fur Kommunalwirtschaft, Dresden. 1965.

Klett, A. Saubere Stadte-Schonere Städte (Clean Towns – More Beautiful Towns). – Der Stadtetag, Issue 12. 1964.

Klotter, H. E. Karbidschlamm – seine Verwertung und Ablagerung (Carbide Sludge – Its Utilization and Dumping). – Der Stadtetag, Issue 2. 1965.

Koch, R. Sechsjahrige praktische Erfahrungen in der Anwendung von Mullkompost (Six Years of Practical Experience in Applying Refuse Compost). – Der Deutsche Weinbau, Issue 19. 1964.

Koglin, W. Entstaubung mit Elektrofiltern (Dust Collection with Electrostatic Precipitators). – Aufbereitungs-Technik, 5th year of publ., Issue 11. 1964.

Knoll, K. H. and D. Strauch. Ein neuer Weg zur Aufbereitung und Verwertung von Siedlungsabfallen (A New Method of Processing and Utilizing Municipal Waste). – Der Stadtetag, Issue 5. 1964.

Krichbaum, H. Private Mullverbrennungsanlagen und kommunale Mullabfuhr (Private Waste Incineration Plants and Municipal Refuse Collection). – Der Stadtetag, Issue 11. 1964.

Kruse. Die festen und flussigen Abfallstoffe in Hinsicht auf ihre gesundheitlichen Gefahren fur die Allgemeinheit (Solid and Liquid Wastes with Regard to Their Public Health Hazard). – Korrespondenz Abwasser, Informationsblatt fur das Abwasserwesen, No. 6, Bonn. 1964.

Lancoud, F. Installations municipales de traitement des eaux usées et des ordures ménagères. – Bulletin de l'A.R.P.E.A., No. 4, juillet 1964, Association romande pour la protection des eaux et de l'air, Geneva, 1964.

Langer, W. Geordnete Mullablagerung (Sanitary Landfill). – Der Städtetag, Issue 1. 1965.

Leib, H. Technische Anforderungen an Anlagen zur Beseitigung nicht faulnisfähiger fester Industrieabfalle (Technical Requirements of Plants for Disposal of Nondigestible Solid Industrial Waste). – Schweizer Journal, 31st year of publ., No. 2. 1965.

Livshutz, A. Aerobic Digestion (Composting) of Poultry Manure. – World's Poultry Science Journal, Vol. 20, No. 3. 1964.

Mahlke, H. Wasser in der Strassenreinigung (Water in Street Cleaning). – Der Städtetag, Issue 10. 1964.

Mahlke, H. Fahrzeug- und Gerateschau Munchen 1964 (Vehicle and Device Show, Munich 1964). – Der Städtetag, Issue 12. 1964.

McGauhey, P. H. Processing, Converting and Utilizing Solid Wastes. – Compost Science, Summer, Vol. 5, No. 2. 1964.

Miller, M. The Treatment of Refuse in the Soviet Union. – Compost Science, Summer, Vol. 5, No. 2. 1964.

Müller, W. Mullverbrennungsanlage der Stadt Ludwigshafen (Waste Incineration Plant of the Town of Ludwigshafen's). – Städtehygiene, Issue 12, 1964.

Neidl, G. Neuere Methoden der Mullaufbereitung (Recent Methods of Waste Processing). – Wasser, Luft und Betrieb, No. 12, Krausskopf-Verlag Mainz. 1964.

Neveux, M. Traitement et Utilisation dans l'agriculture des eaux usées et des déchets solides des collectivités rurales et urbaines en France. – Ministère de l'agriculture, Direction Générale du génie rural et de l'hydraulique agricole, Imprimerie Nationale Paris. 1962.

Noack, W. Die Schlammbehandlung in städtischen Kläranlagen unter besonderer Berucksichtigung der Schlammvergasung (Sludge Treatment in Municipal Sewage Plants with Special Regard to Sludge Gassification). – Forschungsberichte des Landes Nordrhein-Westfalen, No. 1251, Westdeutscher Verlag Koln-Opladen. 1964.

Novak, B. Beitrag zur Methodik des Studiums mikrobieller Umwandlung organischer Stoffe im Boden (Contribution to Methods of Studying Microbial Conversion of Organic Substances in the Soil). – Albrecht-Thaer-Archiv, Vol. 7, Issue 7/8. 1963.

Novak, B. and S. Franklova. Einfluss von einigen Inhibitoren auf die Humusbildung (Influence of Some Inhibitors on Humus Formation). – Zentralbl. fur Bakteriologie, Parasitenkunde, Infektionskrankheiten und Hygiene, 2, Paragr. 117 and 118, Jena. 1964.

Nowak, W., A. Netzsch-Lehner, and L. Seibold. Wirkungen einer Mull-Klarschlamm-Kompost-Dungung auf den Mikroorganismenbestand (Effects of Waste-Sewage Sludge-Compost Fertilization on the Quantity of Microorganisms). – Stadtehygiene, Issue 10. 1964.

Paccolat, M. Ordures ménagères: Incinération ou compostage. – Bulletin de l'A.R.P.E.A., No. 6, Nov. 1964, Geneva. 1964

Peyer, E. Die Bodenverbesserung im Rebbau mit Mullkompost (Soil Improvement in Viniculture with Refuse Compost). – Internat. Jahrbuch chemische Industrie, Pro Aqua 1965, Solothurn. 1965.

Popel, F. Ist die Faulung von Abwasserschlamm ein wirtschaftliches Aufbereitungsverfahren? (Is Digestion of Sewage Sludge an Economical Process?). – Kommunalwirtschaft, Issue 9, Dusseldorf. 1964.

Riebel. Neues Verfahren zur Räumung der Schlammtrockenbeete (New Methods of Clearing Sludge Drying Beds). – Stadtehygiene, Issue 11. 1964.

Rohde, H. O. Voruberlegungen und Versuche zur Grundung der Schlammentwasserungsanlage bei der Emscherflussklaranlage der Emschergenossenschaft (Preliminary Considerations and Experiments for Founding a Sludge Dewatering Plant at the Emscher River Sewage Treatment Plant of the Emscher Cooperative). – Technischwissenschaftliche Mitteilungen, Issue 6, Emschergenossenschaft, Lippeverband, Kronprinzenstr. 24, Essen. 1964.

Rub, F. Entstaubung der Rauchgase von Dampfkesselanlagen (Flue Gas Dust Collectors for Steam Generator Plants). – Wasser, Luft und Betrieb, No. 11, Krausskopf-Verlag Mainz. 1964.

Rub, F. Karschlammtrockung und Abluftreinigung (Drying of Sewage Sludge and Cleaning of Used Air). – Wasser, Luft und Betrieb, No. 12, Krausskopf-Verlag Mainz. 1964.

Samans, H. Hygienische Beseitigung von Marktabfallen (Hygienic Disposal of Market Waste). – Stadtehygiene, Issue 10. 1964.

Sander, H. P. Die Genehmigungs- und Erlaubnispflicht fur Anlagen zur Verbrennung von Industrieabfallen und Produktionsruckstanden (Compulsory Approval of and Permission for Plants for Incinerating Industrial Waste and Production Residues). – Wasser, Luft und Betrieb, No. 12, Krausskopf-Verlag Mainz. 1964.

Sanford, C. F. Why Elmira, New York Chose Composting. – Compost Science, Summer, Vol. 5, No. 2. 1964.

Schickhardt, K. E. Mull und Gewasserschutz (Waste and Water-Body Protection). – Wasser und Abwasser, Issue 11, Ctterfing. 1963.

Schulze, K. L. The Fairfield-Hardy Composting Pilot Plant at Altoona, Pa. – Compost Science, Autumn-Winter, Vol. 5, No. 3. 1965.

Schwann, H. Abfallbeseitung-ohne Sinn und Verstand (Waste Disposal – without Sense and Reason). – Die demokratische Gemeinde, Issue 8, Bonn. 1964.

Seifert, A. Zur landwirtschaftlichen und gartnerischen Verwertung stadtischer Abwasser (On the Agricultural and Horticultural Utilization of Municipal Sewage). – Stadtehygiene, Issue 9. 1964.

Spohn, E. Kein "Stummer Fruhling" in Kreislauf des Lebendigen (No "Silent Spring" in the Circulation of Living Matter). – Mitt. d. Vereins fur Naturwissenschaft und Mathematik, Issue 27, Ulm. 1964.

Spohn, E. Das Blaubeurer Kompostwerk (The Blaubeurer Composting Plant). – Wasser und Abwasser, Issue 1 – 2, Otterfing. 1965.

Stalmann, V. Versuche zur Schlammentwasserung mit einer Kammerfilterpresse (Attempts at Sludge Dewatering with a Chamber Filter Press). – Technisch-wissenschaftl. Mitteilungen, Issue 6, Emschergenossenschaft, Lippeverband, Kronprinzenstrasse 24, Essen. 1964.

Stead, F. M. Solid Waste Collection and Disposal Systems, Ecology, Administration, Research. – Compost Science, Spring, Vol. 5, No. 1. 1964.

Stead, F. M. Social and Legal Implications of Organic Waste Management. – Compost Science, Autumn-Winter, Vol. 5, No. 3. 1965.

Stickelberger, D. How the Caspari Compost System Works. – Compost Science, Spring, Vol. 5, No. 1. 1964.

Surber, E. Die Verwendung von Mullkompost in der Forstwirtschaft (Application of Refuse Compost in Forestry). – Chemische Rundschau No. 25, 3.12.1964, Solothurn. 1964.

Swanwick, J. D., F. W. Lussignea, and R. C. Baskerville. Recent work on the Treatment and Dewatering of Sewage Sludge. – International Conference on Water Pollution Research, London, Sept. 1962, Pergamon Press Oxford-London. 1964.

Tanner, R. La production d' énergie par les usines modernes d' incinération des ordures. – Techniques et Sciences Municipales, No. 7, Paris. 1964.

Tanner, R. and R. Bopp. Die Technik der Müllverbrennung (The Technique of Waste Incineration). – Pro Aqua 1965, Verlag Grob AG, St. Gallen. 1965.

Täuber, F. Die Industrie auf der INTAPUC (Industry at the INTAPUC). – Stadtehygiene, Issue 10. 1964.

Teensma, B. Guideliness for Composting Raw Ground Refuse. – Compost Science, Autumn-Winter, Vol. 5, No. 3. 1965.

Tietjen, C. Conservation and Field Testing of Compost. – Compost Science, Spring, Vol. 5, No. 1. 1964.

Tope, O. Aktuelle Fragen der Strassenreinigung (Topical Problems of Street Cleaning). – Der Stadtetag, Issue 12. 1964.

Toth, S. J. Agricultural Uses for Hardboard Plugs. – Compost Science, Summer, Vol. 5, No. 2. 1964.

Toth, S. J. Agricultural Value of Dried Poultry Manure and Bedding. – Compost Science, Autumn-Winter, Vol. 5, No. 3. 1965.

Tronko, W. Grossraumige Abwasser- und Abfallbeseitigung (Large-Scale Sewage and Waste Disposal). – Die Wasserwirtschaft, Issue 2, Stuttgart. 1965.

Visser, S. A. Decomposition of Organic Materials in the Tropics. – Compost Science, Autumn-Winter, Vol. 5, No. 3. 1965.

Weststrate, W. A. G. Composting of City Refuse. – Compost Science, Spring, Vol. 5, No. 1. 1964.

Wiethaup, H. Internationale Massnahmen gegen Luftverschmutzung (International Measures for Air Pollution Control). – Wasser, Luft und Betrieb, No. 12, Krausskopf-Verlag Mainz. 1964.

Wiley, J. S. A Report on Three Manure Composting Plants. – Compost Science, Summer, Vol. 5, No. 2. 1964.

Wisnewski, H. Müll in der Schmelzkammer (Waste in the Melting Chamber). — VDI-Nachrichten No. 14, 7.4.1965, Düsseldorf. 1965.

Witte, O. Müllwagen für Sperrmüll (Refuse Trucks for Bulky Refuse). — Der Städtetag, Issue 3. 1965.

Wolfskehl. Die Mullverbrennungsanlage der Stadt Darmstadt (Waste Incineration Plant of the Town of Darmstadt). — Kommunalwirtschaft, Issue 10, Dusseldorf. 1964.

Wuthrich, F. C. Der Schutz von Luft und Wasser als nationale Aufgage (Protection of Air and Water as a National Task). — Neue Züricher Zeitung, No. 3941 v. 22.9.1964. 1964.

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THE THIRD INTERNATIONAL CONGRESS OF IAM ON THE DISPOSAL AND UTILIZATION OF SOLID MUNICIPAL WASTES

By Dipl. Ing. K. Wuhrmann and Dr. W. Obrist, EAWAG Zurich

The third congress of the International Association for Waste Research took place in Trento (Italy) from 24 to 29 May, 1965. About 600 persons from European and non- European countries congregated in the hospitable town and took part in the proceedings excellently organized by the "Associazione Nazionale di Ingegneria Sanitaria" (ANDIS). In addition to major and supplementary speeches and discussions, a specialized exhibition and an inspection of the refuse composting plants in Trento, Verona, and Merano demonstrated the technical realization of waste disposal.

In his inaugural speech, IAM President, Prof. Dr. O. Jaag, Zurich, pointed out the universality of the social problems which find their expression in an increasingly close cooperation of the participating international (INTAPUC, IAM, UNO) and national organizations.

The major and supplementary speeches are contained in full in one volume published by ANDIS in German, English, French, and Italian, and available for the price of Lit. 7,500. They may be ordered from: Sig. G. Grassi, Segretario del Congresso GISRUS, Via Belenzani 3, Trento (Italy).

Brief summaries of some major speeches and their supplements.

W. Langer, Berlin

Influence of Deposited Solid Wastes on Surface and Subterranean Water Bodies

Solid waste deposits may cause the deterioration of groundwater through extracted substances. The speaker examined various groups of substances for consideration, as follows. Because dissolved mineral salts are not retained in any soil zone, they form a source of danger to hygiene in the groundwater. Organic substances perceptible by smell or taste are even more undesirable because they may be noticeable in even the lowest concentrations.

Many of these substances can be decomposed bacteriologically; there, the soil structure, the duration of their presence, and possibly the flow distance also are important. The speaker explained the procedure for determining and examining the groundwater deterioration with several characteristic examples. He suggested feasible measures to take when groundwater contamination has been determined: prevention of extraction by partitioning, and pumping off.

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H. M. Ellis, Bristol

Supplementary speech on the same subject

This speaker described a number of experiments carried out since 1954 in Bristol (Great Britain) to determine the contamination in groundwater caused by infiltration of rain water through a layer of solid municipal wastes deposited on the ground. Here, too, a limited aerobic cleansing action and filtering effect was found, depending on the subsoil. Recommendation was made to improve the quality of the infiltrated water by damming up the places of deposits with such inert materials as gravel or excavated earth, or to clean in a settling tank infiltrated water collected from a drainage system.

R. J. Black, Washington

American Experience in the Field of Controlled Tipping

Municipal wastes in the U. S. differ in kind and composition from European wastes, but the problems of controlled tipping are about the same.

In the U. S., controlled tipping is very widely used, and the method has been highly developed over many years. Great emphasis is laid on economic mechanization, illustrated by the speaker with several examples. A special variant is "controlled deposition-incineration," i.e., intentional incineration on the deposit. This is supposed to have the same effect, namely better volume utilization, as constant wetting of the deposit, which is also practised.

K. Wuhrmann, Zurich

Possibilities and Limits of Different Disposal Methods Within the Framework of the Entire Problem of Waste

In assessing different methods of waste disposal, the major criteria are based partly on techniques of waste disposal and partly on philosophical or purely economic considerations. The cooperation of the biologist, the chemist, the process engineer, and the industrial scientist is necessary to define the possibilities and limits.

A survey of the Swiss conditions shows that while disposal of various kinds of civilization's wastes is incomplete, this is especially true of sewage sludge. Explanation was made of the most important provisions of the existing processes for comprehensive disposal.

It seems important to coordinate selected waste-disposal processes and sewage-sludge disposal; the latent heat contained in waste is of particular importance.

H. Straub, Baden-Baden

Supplementary speech on the same subject

An important criterion for assessing various processes is the amount of material to be deposited. This may range in volume from 100% in controlled tipping to about 10% in composting. The process which lies between them is incineration. As regards costs, controlled tipping is most expensive; composting, with smaller investment, is next; and incineration is last.

H. Rousseau, Paris

Waste-Incineration Plants with Heat Utilization

Almost all the larger waste incinerating plants in Europe have steam generators so as to utilize the latent heat of refuse. Only in small plants, where heat removal is difficult, utilization of these calories is dispensed with. On the other hand, in the U. S. there is hardly any heat utilization at all, as this requires additional costly installations for cooling flue gases so as to clean them before their emission into the atmosphere.

Comparison of the advantages of these two systems, with and without heat utilization, requires thorough investigation of operating costs.

In Europe, the heat is used in winter largely for heating. In summer, there are two variants: relaxation of the steam in a cooling tower, and use of the energy in a group of condensing turbines. These two versions are compared for a plant which processes 400,000 tons of refuse per year. The calculation yields a net operating profit due to current generation of 5 million Ffrs. per year, which permits amortization at an interest rate of 7% of the required additional equipment within nine years.

P. D. Fairlie, Glasgow

Incineration Plants Without Heat Utilization

In Great Britain, just as in the U.S., incineration without heat utilization is carried out almost exclusively. However, the difference between the countries is that Great Britain usually practices salvage, whereas the U.S. does not. The speaker examined the question of heat utilization with reference to experience in Glasgow, where current was generated in a 600 ton/day plant (Govan) from 1936 to 1945.

For that purpose the plant required eight boiler units and two 5-MW sets. The power sold decreased during the war from the initial 34 million kWhr per year to 3.5 millions. The income thus produced was out of proportion to the operating costs. A newly built plant of that type has a specific investment of £ 90 per kW as compared with 45 £/kW for large power plants.

Accordingly, power generation was out of the question for the new plant, Polmadie. Because district heating is also undeveloped in Great Britain, it was decided to forego heat utilization as well. The speaker dealt in detail with the transition to mechanical grates and with questions of air pollution control.

K. Schwarz, Essen

Measures for Preventing Air Pollution by Waste-Incineration Plants

Waste incineration yields, in addition to flue gas, various noxious substances, the composition and quantity of which vary constantly. Apart from a technically favorable layout of incineration equipment, careful processing, efficient separators and filters, or additional ignition (e.g., catalytic), as well as high stacks, are required to avoid an impermissible increase in immission concentration.

Small plants are in an unfavorable position concerning all the aforementioned operation factors, compared with large plants which can economically maintain the emission values now required in Germany. In permanent operation, 200 mg/m^3 STP are required for solid substances in small plants; in large plants less than 150/m^3 STP, according to previous load.

Special problems arise in the exclusive or joint incineration of industrial wastes, because of the chlorides and hydrogen chlorides from plastics. Furthermore, incomplete combustion of hydrocarbons can set off smog formation which is particularly feared in large agglomerations.

P. Chovin, Paris

Investigation into Dust Sedimentation in the Vicinity of a Waste-Incineration Plant

The foregoing lecture can be complemented by the investigations in Paris where dust immissions near a waste-incineration plant were compared with those in the rest of the city area. On the basis of the statistically substantiated values found, the plant in question was equipped with dust separators for the flue gas. Dust emission not connected with flue gas is also mentioned.

E. O. Riedel, Düsseldorf

On the Usefulness of Mechanical Comminuting and Screening of Refuse

The speaker discussed the assumption that refuse must be comminuted for further processing, which is usually done in composting. This leads to technological block diagrams of comminution and screening processes, and various functions and concepts with emphasis on the extreme nonhomogeneity of refuse in reference to its material properties, size, and composition. The resulting consequences were pointed out:

1. Choice of process according to initial substance (bulky material or domestic refuse).
2. Choice of process according to the desired comminution effect (incineration or composting).
3. Choice of process according to the desired separation effect (metals, glass, plastics).

Correspondingly, the machines used are shears for bulky material, waste press shears and percussion mill for bulky substances, mill rasp and hammer mill for domestic refuse, and screen drum and vibration screen for separating substances before or after composting.

The special advantages and disadvantages of such usual comminution methods as pressure, impact, shear, tear, friction, or shock have to be compared on the basis of results achieved and operating costs required. Equipment which works without much maintenance is desirable for large plants.

A. Erbel, Simmern

Physical Processing of Domestic Refuse

Refuse processing is decidedly dependent on the method of removal, e.g.:

Preparation at the place of incidence,
Removal in the refuse van,
Removal with reloading, or
Removal with subsequent swilling.

The first method, effected in the so-called refuse beater, is unimportant because, in general, neither the sewage network nor the sewage treatment plant is large enough for such a load.

In removal by refuse van, compaction of refuse and comminution are of increasing importance, especially with bulky substances.

In controlled deposition, compaction is also indispensable, but is achieved largely by bulldozers.

Processing prior to composting was discussed by Riedel.

As preparation for refuse incineration, some comminution to increase the surface may be favorable, but it can have the opposite effect.

H. J. Banse, Braunschweig, and D. Strauch, Giessen

Importance of Preliminary Digestion in Composting

The speakers examined the microbiological and hygienic effects of good preliminary digestion in the composting of domestic refuse based on the Dano-biostabilizer. They were able to determine the boundary ranges of aeration and moisture content within which digestion conditions are favorable and do not create an odor nuisance. Destruction of vegetative forms of pathogenic microorganisms can be proved, but subsequent short-term windrow composting is necessary if spore-forming bacteria are to be rendered harmless. Thus, controlled preliminary digestion in composting refuse and sewage sludge is important because of the relatively quick transformation of these substances into a hygienically unobjectionable product with good structure, and rich in organic substances.

B. Teensma, Amsterdam

Supplementary speech on the same subject

The subject was complemented by descriptions of Dutch experience with the process. Intensive preliminary digestion without fermentation cells also can be achieved in lower windrows of about 45 cm height within 10 to 14 days. Intensive fungus growth causes intensive decomposition, and subsequent post-ripening in high windrows for 3—4 weeks can shorten the total digestion time considerably. However, this composting method requires much space.

Y. Maystre, Geneva

The Problem of Smell in Composting

The speaker dealt with this topical problem by referring to the plant in Villette near Geneva; it has been in operation for more than four years and is located near a settlement. At one time there was smell nuisance, and many experiments were made to remove the decomposition gases developing in the plant. Where no satisfactory results were reached by washing, incineration, deodorization, ozonization, and application of active charcoal, ground filtration proved to be a final solution. Since then, that method has been applied very successfully in other plants.

R. Braun, Zurich

The Problem of Sewage Sludge

In the conditions prevailing in Central Europe, removal and storage of sewage sludge encounters increasing difficulties, and various other methods of preparation and removal have become important in processing techniques.

The basic requirement is the greatest possible concentration of the sludge, because of the reduced transport weight on the one hand, and because of consequently more favorable handling and usefulness of the remaining solids on the other hand. The first stage of concentration, and also the cheapest, is thickening, in which up to 15% enrichment of solids can be achieved. This is followed by desiccation in drying beds, centrifuges, vacuums, or press filters up to the degree of 30 — 40% solid content. The spadable sludge is suitable for composting or — usually after additional drying — incineration, or as granulated filling material. However, so far no known artificial desiccation or drying process is technically and economically absolutely satisfactory.

On the other hand, there is an interesting tendency to revert to natural desiccation processes, obviously due to economic considerations. However, artificial desiccation must be carried out where, for reasons of space, drying beds at a practicable distance are out of the question. This poses the question of further utilization of the digestion tanks in that various processes are already known which permit the processing of fresh sludge too. The question is whether, with the emergency solution of wet removal no longer available, the operating risk is not too great now, considering that there are no digestion tanks and corresponding hygienization.

E. de Fraja Frangipane, Milan

The Position and Future Development of Waste Disposal in Italy

Since 1955, measurements have been carried out in Italy in reference to the quantities of refuse. As elsewhere, large settlements were found to have slightly higher average values than smaller ones. It seems that with a range of 150 to 300 kg/inhabitant/year, the usual values under European conditions were attained.

So far, uncontrolled tipping is predominant, but composting and incineration are gaining in importance. The speaker dealt thoroughly with composting with a view to the possibilities of its application, which is particularly important in those

Italian regions where intensive crops are cultivated, but there is little cattle husbandry. In that case, the compost supplies the soil with humus.

DISCUSSION

The following contributions to the discussion were submitted to the Secretariat in writing:

1) Contribution by M. H. Rousseau, Paris, on the subject "Influencing Above-Ground and Underground Waters by the Deposition of Solid Substances":

The papers by Messrs. W. Langer and H. M. Ellis were very interesting and reassuring, mainly because they showed that it is technically feasible to control pollution of underground waters by controlled tipping.

Despite that, it is preferable not to risk unnecessary difficulties, and to employ an expert for the hydrogeological examination of the area considered for controlled tipping. This method is used in the Paris region, and no special pollution problems have arisen.

Our tippings are of the conventional type, but usually very extensive. Each year about 5 or 600,000 tons of waste are deposited. The most important dumps receive annually 250,000 tons of waste by rail. It is then sufficient to observe the well known principles of the method to ensure trouble-free operation.

2) Contribution by M. Félix Prat, Toulouse, on the subject "Possibilities and Limits of the Different Disposal Methods Within the Framework of the Entire Problem of Waste":

The main speakers as well as the supplementary speakers described very well the possibilities of various methods of disposal of domestic refuse within the framework of the entire problem of waste. They did valuable work, for which we owe them thanks, for they endeavored to broaden the all too narrow points of view of specialists, and to treat the problems on a broader plane.

We believe, however, that this changeover to a higher plane should be even more pronounced, and it would be desirable to no longer treat the various methods of disposal within the framework of the problem of waste, but within the broader frame of reference of living conditions and human requirements.

I do not claim to treat this subject myself, but I wish to emphasize a few incontrovertible points:

In our time, foodstuffs are very unevenly distributed. Some nations are very well provided with them, others suffer a shortage. We know that today three out of five persons do not have enough to eat.

To enable every person to eat his fill, it is necessary to distribute the resources better, mainly to increase them. Deserts must be conquered and changed into fertile soils.

Are you not also of the opinion that these considerations should form the basis for the study of the problem of waste? Are we certain that substances, called waste by us, are really worthless for nations that are less well provided? Are not, for instance, kitchen drain water and kitchen waste used as fodder for animals which then become excellent food for man?

Why should we tenaciously maintain that the aim to be attained is the disposal of waste? It would be desirable to try and convert this waste so that it would yield a positive contribution in the struggle for life.

Let us assume that we decided to use the refuse of a city of about 10 million inhabitants for that purpose. The fertilizers thus gained would, according to experience, provide an increase in yield of 4,500,000 tons of potatoes or 1,5 million tons of corn. In other words, the refuse per person converted into means of soil amelioration would provide an average increase in yield of 450 kg potatoes or 150 kg corn.

The objection could be made, as it has in the past, that such supplementary quantities of food are still insufficient. Is that a sufficient reason to neglect them? Are countries which are well provided with food entitled to destroy such a source of foodstuff under the pretence that their own requirements are satisfied? This view is all the more untenable because the confortable method of destruction is usually more expensive than composting. If these countries do not want to increase their food production, they can compost their waste and put the surplus yield thus obtained at the disposal of nations suffering from undernourishment. That way they will do not only a good deed but also good business.

The question of waste disposal should not exist at all in countries that are poorly supplied with food. For them, the utilization of waste and composting are means of survival.

It is not only criminal to destroy such a source of life, its neglect and the toleration of rotting dumps near cities should cause strong guilt feelings in those responsible.

It is just as impermissible to destroy waste as to ignite a petroleum source. The utilization of this waste for increasing the available quantity of food is a duty of solidarity for some nations, for others a vital necessity.

For us technicians, the main problem is, in my opinion, not the assessment of the limits of disposal methods, but the investigation of ways of converting waste unrestrictedly and under the most favorable conditions into means of soil amelioration.

In this sense we should at least endeavor jointly – with the aid of the more or less satisfactory means at our disposal – to find desirable improvements, for in this field, as everywhere else, there is no perfect and definitive solution.

3) Contribution by M. H. Rousseau, Paris, on the subject "Special Questions of Incineration Techniques":

a. Operating Results of the Waste Incineration Plant in Issy-les-Moulineaux

At the time I wrote the report on waste incineration with heat utilization, in the fall of 1964, I did not yet have the first results of the new plant in Issy-les-Moulineaux, which started operating only in January 1965.

The four furnaces were fired successively between 13 January and 17 May, 1965; this was done with no special incidents, and continuous operation was inaugurated a few weeks after the first firing.

The back-pressure set was connected to the electric grid on 11 March 1965; since 22 March it has been in uninterrupted operation.

The condensation-turbine set will be put into operation as late as the end of 1965.

During the first four months of operation – between the middle of January and the middle of May – 95,000 tons waste were incinerated, 180,000 tons steam and 2,900,000 kwhr electric power were produced.

These excellent results testify to the extraordinary capacity of the incineration furnaces. Since the first firing in January, the first furnace has remained in operation – under full load – for 93% of the entire time.

b. Behavior of Grates in Case of Raw Refuse

I want to reassure our British colleague, Mr. Fairlie, as to the performance of our grates, both in Saint-Ouen with the Volund furnace and in Issy-les-Moulineaux with the Martin furnace.

There were no cases of wire catching or large pieces getting jammed. After a few hours of its operation, the first furnace in Issy-les-Moulineaux had two old bicycles on the grate simultaneously; a few days later two mattresses with metal springs were on the grate. These did not impede the incineration process, or damage the equipment, and evacuation proceeded normally; these pieces appeared in the slag no differently from ordinary metal cans.

c. Dust Removal (concerning a remark by Mr. Maystre)

Here I would like to clear up a possible ambiguity in regard to the difficulties encountered by T. I. R. U. in dust removal.

In old plants this problem indeed existed, but it was solved in a manner satisfactory at that time.

Now great strides have been made owing to electrostatic dust collectors; these are fairly expensive, however. In Issy-les-Moulineaux, a dust removal rate of 98% was attained. With a dust concentration of 4 g/m^3 STP at the inlet of the dust collectors, 0.08 g at the stack outlet were achieved.

These results are comparable to those of the best French power stations.

d. Reply to the discussion by an American colleague

I apologize to my American colleague because my statement concerning the lower calorific value (PCI) of the waste in our plants was misunderstood: the value mentioned, viz., 1,000 cal/kg, is only the lower limit below which it never decreases.

The present lower calorific value amounts to 1,800 cal/kg, i. e., 3,750 BTU/lb. It is very close to the values given in the U.S.A.

4) Contribution by M. H. Rousseau, Paris, on the subject "Special Questions of Composting Techniques":

The main interest of the congress obviously lies in the exchange of experience, but conditions in different cities can differ greatly. Experiences therefore do not always coincide, and they may even point in opposite directions.

The dimensions of pieces contained in domestic refuse are unrelated to the amount of refuse received, so that in small plants it is sometimes indispensable to comminute large pieces or even sort them, whereas this is not necessary in large plants the furnaces of which are provided with wide intake shafts and can receive anything.

In two of our Paris plants producing a substance for agriculture, the refuse must pass through drum screens with a 75 mm mesh. Iron particles which have been removed from the fine screenings are comminuted in hammer mills while the screen residue is incinerated.

For a long time, we have been selling about 250,000 tons of this product annually. Shipments, which often amount to 1,000 tons per day, are made by rail or road. The farmers stack this material at the edges of their fields and let the stacks decay for 3 or 4 months. This simple method makes it possible to sell large quantities daily; there is no storage, which would be impossible anyway, considering the considerable quantities involved.

Many cities let the refuse decay in their own plants, and they are thus in a position to sell an instantly usable compost. This is also done in France, but some regions have certain difficulties connected with the official definition of compost, especially labeling and invoicing.

It would be interesting to know whether this problem also exists in other countries, and whether there are regulations such as there are for the pharmaceutical industry, which stipulate that contents of products for sale have to be specified. Is it, for instance, permitted to use freely the name "compost" or other similar designations for products made in this manner, whose properties are certain, but whose composition cannot be guaranteed?

5) Contribution by Dir. Glockner, Stuttgart, on the subject "Special Questions of Composting Techniques":

The previous contributions tend strongly toward further improvement of the techniques of composting refuse. I would consider the treatment of the complex of problems incomplete if the simplification of refuse composting were not also considered. This is a unique situation which, in my opinion, has received insufficient systematic treatment. The formation of communal corporations is discussed increasingly, but as a rule only for the purpose of operating either a communal waste incineration plant or a communal composting plant. Precisely for corporations, however, there is the possibility of a combination of decentralized local refuse composting with modern central large-scale waste-incineration plants, which should at long last be examined because it could open up new outlets for refuse compost. If refuse composting and waste incineration are accorded equal rights in the sense that all coarse materials which have a high calorific value are screened, the remainder is then suitable for simplified composting because the quantities involved are suitable and easily controlled. To an equal extent, the incineration technique is simplified because the well known difficulties attendant on the incineration of general domestic refuse are radically reduced. Precisely those substances which are identical with the material suitable for composting and which cause difficulties on the grate are then removed. This greatly simplifies the planning of a central incineration plant, from both the technical and the economic points of view. Especially are contractual arrangements, by which smaller towns join the incineration plant of a nearby larger city, made considerably easier if these towns supply only screened coarse refuse which is of constant composition throughout the year. Transport costs are also reduced, because not only is the total quantity reduced, but the heavy and moist components of the refuse are used at the place of incidence.

6) Contribution by Dr. K. H. Knoll, University Giessen, on the subject "The Problem of Sewage Sludge":

Among the tasks of hygiene is the unobjectionable disposal of domestic and industrial waste. The aim is to prevent such substances from causing diseases or epidemics which may affect man, animals, or even plants.

This means that the parasites and germs contained in solid and liquid domestic waste have to be destroyed.

It is well known that from the epidemiological point of view sewage sludge poses the greatest danger because it has to be considered infectious always — even after thermic digestion in digestion tanks, lasting the usual period. Special problems are connected with sewage sludge, which Dr. Braun will discuss; these problems become steadily greater as more sewage treatment plants are built in which sewage sludge originates and must be removed.

The danger of infection from the agricultural use of sewage sludge has already been pointed out, and Dr. Strauch gave examples of infections that happened in our district. This is precisely why disinfection of sewage sludge is the most important condition in waste disposal, and is carried out in common composting of sewage sludge and refuse. This brings me to answer the special question. Within the framework of research projects dealt with by the joint university institutes in Giessen (Arbeitsgemeinschaft Giessener Iniversitätsinstitute), the following results have been achieved so far:

1. In windrow composting, a period of two to three weeks, if the initial material with a moisture content of 40 — 60% attained a maximum temperature of 50 to 55°C, is sufficient to destroy parasites and infectious organisms in the sense of biological self-purification. Even sporogenes — in the test, **Bacillus anthracis** which after 70 years in the soil is still infectious and virulent — are thereby destroyed.

2. Treatment with fermentation cells considerably shortens disinfection time. With the DANO process, parasites and disease bacilli are destroyed after 5 – 7 days, also at a maximum temperature of 55°C. For safe destruction of sporogenes, postcomposting for 2 or 3 days after treatment with fermentation cells is sufficient.

Other processes still under investigation by the joint institutes in Giessen promise even speedier disinfection; however, these investigations have not yet been concluded.

7) Contribution by Dr. D. Strauch and Dr. K. H. Knoll, University Giessen, on the subject "Problem of Sewage Sludge":

On the basis of Liebmann's data that for killing parasite eggs in unheated digestion tanks 3 months are sufficient, and in heated digestion tanks 2 months are time enough, the speaker states: "In this respect, digested sludge can then be designated unobjectionable."

We are unable to follow this line of argument because it is generally known that most sewage treatment plants produce an amount of sludge which makes it simply impossible to maintain decay times of 8 weeks or more. The decay times ascertained by Liebmann, however, and their maintenance are decisive for the hygienic assessment of sewage sludge for occurrence of parasite eggs. If these periods are not maintained, the sewage sludge cannot then be considered hygienically safe. If it is used in agriculture, the danger persists of the closed chain of infection through domestic animals, eventually leading again to human infection by disease-carrying parasites.

The speaker points out to the hygienists that despite more than 50 years of sewage-sludge application in agriculture, there is not one known case in which infection of animals or humans could be traced unambiguously to the application of properly digested sewage sludge.

To this, we can only repeat that within a short time there will probably be less and less properly digested sewage sludge. In consequence, the hygienic quality of these sludges will also be gradually reduced.

On the other hand, it seems to us, in regard to the Federal Republic, at least doubtful that the use of sewage sludge on pastures for dairy cattle will ever meet with sympathy from the authorities or the public. Agricultural plants which are engaged in dairy production are foodstuff plants, and as such, subject to strict regulation by law. Furthermore, it seems certain to us that the consumer will be less tempted to drink milk if this is bound up with the image of the milk-producing udder being previously in touch with sewage sludge on the pasture. It could be argued that in the stables the cow's udder also touches the excretions of the cows. But there is an enormous difference between contact with such excretions in a stable of healthy animals, constantly under veterinary supervision, and cows contacting sewage sludge of the concentrated excretions of hundreds of thousands or millions of people, among whom are many undetected carriers of infection.

The milk-producing plants are under health supervision, and it is almost impossible for diseases to be transmitted through the milk to humans. Sewage sludge, on the other hand, contains almost all disease organisms in concentrated form so that nothing prevents their further spread by animals to other animals and humans.

In conclusion, we wish to describe four cases in which damage to health was caused demonstrably by sewage sludge or sewage.

Case 1

A fairly large farm contracted with a municipality for the delivery of digested sewage sludge. The sludge, supplied from the digestion tank, was used for agriculture and, additionally, for fertilizing cattle and swine pastures. Soon the cattle contracted paratyphoid, which was identified as paratyphoid B, a variety particularly dangerous to man. In consequence, several animals had to be slaughtered. The economic loss was correspondingly great.

After one year of using sewage sludge the farm found the swine so infested with parasites that some of the animals died, which happens in parasitic diseases only if the incidence is particularly great. On the whole, the breeding and fattening output of this swine herd decreased so much that the owner suffered considerable economic losses.

Case 2

The same farm had a pasture for fattening young bulls. Nearby flowed water drained from the settling bassin of a small sewage treatment plant. The animals succeeded in forcing their way to the drain and drinking water from it. When the fattened bulls came to be slaughtered, they were found to suffer from taeniasis which introduces tapeworm to humans who eat raw or insufficiently cooked or roasted meat. The meat of animals found to have taeniasis is subjected to special treatment which may cause the owner or buyer of such animals considerable economic losses.

This case is not directly connected with sewage sludge. However, if the water from which the bulls' infection resulted had had sufficient time to settle, and the sewage sludge had then been disposed in the pasture, the bulls would have gotten the same disease through the tapeworm eggs contained in the sewage sludge that they got directly from the sewage water.

Case 3

Sewage sludge that had digested for 6 weeks was stored for three weeks in dry beds, and was then supplied to a farm where it was used for fertilizing a cattle pasture. The cattle were driven onto the pasture after a waiting period of 3 weeks. Formerly healthy, the cattle soon were found to suffer from paratyphoid B, with an ensuing considerable economic and financial loss.

Case 4

Several acute cases of diarrhea occurred in a community and these were diagnosed as a Salmonella enteritis infection. Altogether, about 80 persons fell ill, and one case was fatal. Epidemiological investigations traced the infection to a butcher. Further investigations revealed the following facts: owing to an increased demand for meat, one animal had been included for slaughtering without previous examination. This animal had been feeding in a pasture below the village. The village sewage was conducted without cleaning into a collecting basin, the level of which had risen and had flooded the pastures below the village, one of which was where the infected animals fed. This case is similar to the case of infection with so-called calf-typhoid by infected hay, described by Piening.

Further cases: Groundwater and Surface Water Contamination by Industrial Sludge or Solid Waste: a report is being compiled.

From the point of view of hygiene, there is at present no difference between digested and fresh sludge. Both contain large quantities of parasite eggs and disease organisms, and possibly existing small quantitative differences really are of no account. Such experienced investigators as Popp and co-workers emphasize that it is inadvisable to consider agricultural use of sewage sludge less dangerous epidemiologically than the use of sewage itself. The speaker also said that "direct use of fresh sludge in liquid or dehydrated form is out of the question for hygienic reasons. . . . Since fresh sludge is a decidedly unhygienic product, the possibility of direct contact with it by the staff must be avoided." We do not understand why the speaker, who himself considers fresh sludge as decidedly dangerous, wants to accord the digested sludge a special position which it is not entitled to, at least from the point of view of hygiene. We do not have such confidence in the efficiency of all the digestion tanks in operation as to be willing to endorse all the speaker's views concerning the hygienic importance of digested sewage sludge. From a hygienic point of view, digested sewage sludge is safe only if after digestion it has been disinfected by heating, pasteurization, composting, or some other equivalent process.

8) Contribution by Dir. Eberhardt, Stuttgart, on the subject "Problem of Sewage Sludge":

The question of the hygienic disposal of municipal wastes puts the problem of sewage sludge more and more into the foreground. Implementation of the new laws on air-and water-pollution control creates for some communities a burden which far exceeds their financial capabilities. The German Federal Republic, therefore, provides government funds for the construction of sewage treatment plants. However, construction of new and reconstruction of existing sewage treatment plants are only partial solutions of the problem because they do not solve the problems of rational utilization or disposal of sewage sludge. The disposal of industrial sludges, because of troublesome sewage components, further hinders a solution. In the disposal or treatment of sewage sludge, total plant costs must be taken into account; in other words, dehydration, and drying with incineration or treatment have to be assessed technically and economically.

Already several years ago, various publications referred to the flash drying system developed by the CE-Raymond Division in America, and adapted to European conditions by the Kohlenscheidungs-Gesellschaft. The first large-scale installation with eight units has been in operation for 15 years in Chicago's main sewage treatment plant, and another six units have been operating for 10 years; maintenance and operation costs were minimal. The filter cake with 82% water is dried to about 5% residual moisture, and each unit evaporates maximum 9,500 kg water per hour. Up to 500 tons ready plant fertilizer can be produced daily i.e., an annual income of 8 million DM. It is interesting that in the United States — well known for producing cheap chemical fertilizers in large quantities — dried sewage sludge from flash drying plants is also used as fertilizer in agriculture, and that a remarkable profit is obtained from the sale of this product.

The problem of sewage-sludge disposal is a matter of costs and space, which is also determined by dehydration and drying. In the flash drying process, filter cake with up to 85% water content can be processed, the material comminuted in a special cage mill, and brought into close contact with hot gas. The hot gas is aspirated from a special generator or from an existing boiler with a temperature of 700 to 800°C. The dried material is conveyed, with a temperature of about 150°C, by the action of the ventilator to a cyclone separator where the solid part is separated from the liquid. At this temperature, during milling, the smell must be controlled by mixing the liquid with very hot flue gases. The advantage of this method is that the plant can be operated either as a drying and incineration plant or purely a drying plant. Even if fresh sludge is processed, the dried material yields a biologically pure fertilizer for agriculture, and its sale ensures a considerable reduction of operating costs.

The most economical solution of disposing of all the waste from an inhabited area is the combination of incineration with sludge drying through the subsequent heat released. The dried material can be placed on top of the refuse in the incineration chamber and incinerated together with it. Dried sludge has a calorific value of 2,100 – 2,800 cal/kg and corresponds approximately to dry brown coal, with the combustion of which large power plants have had many years' experience.

The flash drying system was developed by taking into account the experience in mill drying coal, and today it represents a complete and highly automated unit. So far, more than 80 units have been built for communal sludge disposal plants, partly combined with waste incineration plants.

The productivity per year would be sufficient for some 22 million inhabitants, i.e., 2.6 million tons filter cake. In addition to the sewage-sludge drying and incineration plants, there are almost 350 operating units for industrial sludge and mill-drying processes.

9) Contribution by Prof. Zygmunt Rudolf, Warsaw, on "Research Work by the Department of Sanitation Techniques at the Warsaw Technical University in the Field of Waste Disposal and Utilization":

For several years now, Polish sanitary engineers have paid a great deal of attention to problems of waste disposal and utilization. The Chair of Sanitary Techniques of the Hygiene and Hydrology Department of the Warsaw Technical University, under the direction of Prof. Z. Rudolf, deals in particular with the study of these problems, and additionally, has a special department for the study of sewage problems. The Chair for Sanitary Techniques is the only one in Poland which trains sanitary engineers, i.e., experts on the aforementioned matters. The research and teaching activities of the Chair comprise the following fields:

1. City sanitation – scientific foundations of planning and operating the installations.
2. Removal and disposal of municipal refuse: examination of the chemical and physical composition of refuse; study of technical disposal methods.
Planning and operating disposal plants.
Technical and economic study of various methods of disposal.
3. Utilization of industrial waste – quantitative and qualitative investigation of the waste from various branches of industry. Study of methods of utilization. Study of technical processes designed for transforming industrial waste into commercial products.

Lectures and practical exercices in laboratories and in the preparation of projects connected with the aforementioned programs are organized for students in their 4th and 5th years of study. Also, this program is obligatory for those aspiring to a doctorate. Two dissertations are already available:

1. **Simultaneous composting of sewage sludge from the viscose and rayon industry and domestic refuse**
(F. Lerczynski)

This dissertation shows the possibility of applying composting methods for the joint treatment of sewage sludge with a high content of organic substances (mainly cellulose), and municipal waste. Decomposition of the amorphous cellulose contained in the sewage sludge was thoroughly investigated. An original method, the "bag method," was used in these experiments, making possible an exact examination of the decomposition process of a certain group of waste from among the entire compost mass.

2. Examination of the most important chemical transformations during municipal waste composting, with a view to reducing the duration of treatment
(K. Skalmowski)

The research lasted several years and yielded numerous experimental values. The chemical composition of waste from cities such as Warsaw, Cracow, and Lodz, and from several smaller towns was examined. The examinations were carried out annually and covered many characteristic city districts.

The results of these investigations make it possible to determine statistically the mean chemical composition of municipal waste in Poland.

It was found that city refuse has a high content of the most important fertilizer substances, e.g.:

organic substances	30 – 40%
organic nitrogen	0.5 – 0.8%
phosphorous in the form of P_2O_5	0.9 – 1.3%
potassium in the form of K_2O	0.1 – 0.2%

City refuse also has a high calorific value: on an average approximately 2,000 cal/kg. The evaluation of the results permitted interesting conclusions to be drawn; these are very useful in selecting disposal methods for different towns, as well as in planning disposal plants.

Experiments for studying the most important chemical processes occurring in municipal waste composting are conducted with open-air compost windrows.

The windrows were ventilated by a radial ventilator, developed by Professor E. Pfeiffer. The material was always replaced after 6 weeks composting.

Chemical examination of the composting process was combined with examination of the interaction of the two main trends of the transformation process: mineralization and humification of organic substances. Many interesting regularities were observed in the humification process, especially concerning the transformation process of fulvic acid. It was found that humification proceeds fairly quickly (depending on conditions, humification ends after a composting duration of 20 – 50 days). Longer composting does not increase the amount of humus substances; on the contrary, losses were found to occur. On the basis of these investigations, a new index of grades of ripeness was determined, and study continues.

At present, the results of the Doctorate Thesis by Mr. Z. Linowski are being evaluated. These investigations concern the influence of meterological factors (air temperature, wind velocity, air humidity, etc.) on the course of windrow composting.

Recently the Chair for Sanitary Techniques began studying composting in artificially aerated fermentation cells. Soon will follow the study of briquette composting according to the system developed by Dr. R. Caspari. Simultaneously with these chemical and technical investigations, economic studies are being carried out concerning the application of different disposal methods in Polish towns with a population of up to 100,000 inhabitants.

Initially the economic efficacy of the mechanization of some operations in stack composting was investigated.

Composting and incineration of waste from towns with 20,000 – 100,000 inhabitants are also being investigated for their economic effect. The latest results of the investigations show that in towns with more than 100,000 inhabitants incineration without heat utilization is preferable to composting.

The economic efficacy of salvage, and the possibilities of utilizing various industrial wastes are also being systematically examined.

Mr. W. Skorupski examines the utilization of solid wastes and sewage sludge from the viscose and rayon industry. The deposition of large quantities of these wastes is difficult, and contributes to groundwater pollution. An investigation carried out in all Polish viscose and rayon industries made possible determination of the properties of these wastes and methods of utilizing them, e.g., the production of insulating material or other such processes suited to local conditions.

An original preliminary dehydration process is being investigated with a view to speeding up dehydration.

Various other problems of the chemical industry are also under investigation, e.g.:

- Regeneration techniques of alum coagulates from sewage sludge derived from sewage treatment;
- Technique of utilizing industrial sewage sludge with high zinc-compounds content, for producing zinc salts.

The application of methods for the treatment and utilization of industrial sewage sludge often makes possible the production of valuable commercial products; the profit thus derived can cover the costs of sewage sludge treatment, and even the costs of sewage disposal.

We believe, therefore, that the problems of solid waste, sewage sludge, and sewage in different plants should be investigated as a common task.

This report mentions only the main problems that are at present investigated by the Chair for Sanitary Techniques.

SOME CRITERIA FOR THE CHARACTERIZATION OF REFUSE DIGESTION

By E. Ahrens, G. Farkasdi, and I. Ibrahim

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Attention is now focussed on rapid composting of refuse in fermentors because it is a space-saving and clean procedure. Therefore, thorough examination of the digestion process seems indicated. Under normal conditions, digestion proceeds at high temperatures, with the release of considerable amounts of corbon dioxide. This indicates intensive activity of the microflora in the fermentors. However, little is known at present about the extent of degradation of the organic matter during the relatively short period of predigestion (3 – 5 days), i.e., which fractions are subjected to the strongest attack. Following is a report on degradation processes recorded in a preliminary experiment carried out at the Multibacto-Tower, Heidelberg. The freshly prepared minced material used for feeding the fermentor served for comparison. At the beginning of the experiment, the material consisted of typical household refuse, without addition of sewage sludge. The digestion effect in the fermentor was examined immediately and the behavior of the two products recorded also during further composting in plastic baskets (1). The baskets measured: ϕ bottom = 33 cm, ϕ top = 48 cm, height = 38 cm.

The physical, chemical and biological examinations aimed at clarifying the following points:

1. The differences recorded immediately after predigestion in the fermentor.
2. Differences in behavior between the two materials during further digestion.

3. The relation between physicochemical and microbiological findings.
4. The effects on nitrogen conversion in the soil of compost differently pretreated but similarly digested further.

The results discussed below are far from complete and their generalization would be premature, as they represent only preliminary examinations. However, they might stimulate similar investigations since a certain amount of information was gained about refuse digestion in fermentation cells during the processes of degradation.

Method

The experiment was set up on 7 Sept. 1963. Each material was tested in duplicate. The two parallel basket sets were filled with 25 kg of 1) fresh minced material, 2) fresh predigested material (henceforth designated "Multihum") straight from the fermentor of the composting plant in Heidelberg, and placed in the cellar, at room temperature 20°C. The room temperature dropped at the end of the experiment (8 March 1964) to about 12°C. The content of water in the fresh refuse amounted to 38.4%, and in the Multihum to 34.0%. At certain time intervals the material was wetted to make up for the water lost. The temperatures were measured daily (with a mercury thermometer) in the center of the baskets, until room temperature was reached.

Samples for gas analysis were obtained from the center of the baskets by means of a glass probe, and analyzed for carbon dioxide and oxygen content with an Orsat-Ströhnlein apparatus.

The material lost by ignition was determined after incineration at 650°C. The loss of individual fractions of the organic matter was determined with the aid of group analysis, after Waksman (2):

Fraction I (soluble in petrol-ether) comprising mainly fats and oils;

Fraction II (soluble in 1.25% solution of HCl) comprising readily degraded compounds, such as sugar, starch, amino-acids, pectin, etc.;

Fraction III (soluble in 70% solution of H_2SO_4) comprising organic components more difficultly degraded, such as cellulose, albuminous compounds, etc.

The number of microorganisms was determined by inoculating specific culture media with serial ten-fold dilutions of the material. The following media were inoculated:

Glucose soil-extract agar for mesophilic and thermophilic aerobic bacteria;
Asparagin nutrient solution for ammonia producers;
Omeliansky nutrient solution for cellulose decomposers;
Malt-extract agar for mesophilic and thermophilic fungi.

In liquid media, the number of microorganisms was estimated according to the respective tables of McGrady, and Hoskins.

All figures represent the average values of each set of two baskets.

For manuring experiments in vessels without vegetation, 500 g soil (Gottingen clayey loess) were mixed with 16.5 g refuse, which is equivalent to a manure dose of 100 t/ha. Manuring was carried out with both fresh refuse and Multihum, and with samples of both after 6, 19, 56, and 121 days of composting. The mixture was adjusted to 18% humidity, and kept in glass vessels of 750 ml capacity at constant temperature, 25°C. The potted experiment lasted 160 days, and samples were removed after 4, 14, 24, 34, 50, 78, and 160 days. The analyses were carried out directly on the fresh soil. The ammonia, or nitrate content, was determined according to the method of Balks and Reekers (3).

Discussion of Results

1. Temperature and gas evolution

TABLE 1. Temperature and gas evolution during composting in plastic baskets

Composting time in days	Fresh refuse			Multihum		
	Temp. °C	O_2%	CO_2%	Temp. °C	O_2%	CO_2%
0	-	-	-	-	-	-
1	47.0	6.5	15.5	36.0	16.0	4.5
2	50.0	7.5	12.5	36.0	18.5	1.5
3	41.0	16.0	4.0	27.0	20.0	1.0
4	23.0	18.0	2.5	23.5	20.0	1.0
5	20.0	-	-	21.5	-	-
6	19.0	19.0	1.0	21.5	20.0	0.5
7 +)	20.5	-	-	18.5	-	-
8	25.0	17.5	2.5	22.0	18.5	2.0
9	27.0	16.5	3.5	22.0	17.1	2.8
10	26.0	17.0	3.1	23.5	17.5	3.1
14	21.0	18.5	1.5	22.5	18.0	2.0

+) Rewetting

Because of the relatively small quantity and large surface of the material no great heat evolution could be expected. Nevertheless, the fresh refuse attained within two days a temperature of 50°C, which dropped rapidly, owing to the considerable heat radiation. After rewetting on the seventh day the temperature rose again slightly and this rise lasted about three days. In the predigested material the maximum temperature attained 36°C, the rise being considerably lower. After rewetting, the maximum of 23.5°C was lower than in the fresh refuse. Two weeks after the experiment was set up, the temperatures recorded in all baskets were the same as room temperature.

Similar relations were established for CO_2-evolution in both variants. The maximum recorded in fresh refuse was 15.5%, almost 3.5 times higher than in Multihum (4.5%). The increase recorded after rewetting was essentially slight, showing no significant difference between the variants. The values recorded in both variants after 14 days were, without exception, below 2%.

The lower temperature and CO_2-evolution in Multihum leads in the conclusion that part of the organic matter was degraded during the preliminary digestion in the fermentor.

2. Chemical analyses

In accordance with Kortleven's statements (4) the percentage of organic substance lost, i.e., C and N content, was calculated per 100 weight units of dry substance of the initial material.

All analyses of the fresh refuse showed that intensive degradation was proceeding in the first days of composting. This process slowed down gradually with advancing digestion. As expected, degradation proceeded most vigorously in the first 6 days in Fraction I (loss 51.9%), and Fraction II (loss 44.2%), whereas in the difficultly decomposing Fraction III, it amounted only to 16.9%. A more pronounced degradation of this fraction started only after 14 days, and at the end of the digestion period attained 64.3%.

TABLE 2. Results of chemical analyses performed at different stages of digestion in baskets

	Compost-ing time in days	Loss by ignition in %		Soluble in petrol-ether in %		Fractions soluble in acids, determined by the amount of $KMnO_4$ used						% N in dry matter	% N corrected to fresh refuse	Ratio C : N
						1.25% HCl			70% H_2SO_4					
		in dry matter	loss in %	in dry matter	loss in %	ml/g	C %	C-loss in %	ml/g	C %	C-loss in %			
Fresh refuse	0	41.9		1.58		722	3.42		730	4.37		0.64	0.54	37.97
	4	37.0	18.8	1.04	39.2	520	2.46	33.9	706	4.23	11.0			
	6	36.5	20.7	0.83	51.9	443	2.10	44.2	667	3.99	16.9			
	14	36.0	21.8	0.71	58.9	432	2.04	45.6	638	3.82	20.4			
	19	35.0	25.7	0.65	63.3	422	1.99	48.2	542	3.24	34.1			
	56	32.8	32.7	0.57	69.0	294	1.41	64.6	368	2.21	56.5			
	121	32.0	35.1	0.46	75.3	234	1.10	72.5	306	1.83	64.3	0.73	0.62	25.42
Multi-hum	0	34.4		0.94		362	1.72		702	4.20		0.54	0.48	36.94
	4	34.6	0	0.76	19.1	365	1.76	0	695	4.16	0.95			
	6	33.7	3.0	-	-	333	1.57	9.9	-	-	-			
	14	32.2	9.2	0.59	39.4	-	-	-	620	3.71	14.3			
	19	31.8	11.3	0.51	47.9	326	1.52	15.1	542	3.24	26.0			
	56	28.9	22.7	0.45	56.4	315	1.49	20.3	346	2.06	54.8			
	121	27.6	27.0	0.45'	56.4	215	1.01	46.5	320	1.91	58.6	0.58	0.46	27.60

Loss of organic matter, or C, calculated per 100 weight units of the initial material

The initial values established by analysis of the Multihum indicate that a considerable part of the readily soluble C-compounds (40 – 45%), above all, were already broken down during preliminary digestion in the fermentor, whereas the C-loss of the difficultly degraded fraction was at this stage very slight indeed.

The C-losses of Multihum during predigestion in the fermentor are evident also from the carbon degradation recorded in the first days of further composting, as well as from the total amount, which was consistently lower than in the fresh refuse. The losses were somewhat lower only in Fraction III and this is explained by the rather limited degradation of this fraction in the fermentor.

The Multihum was found to contain 25% less N than the fresh refuse. This may be due either to a lower initial content, or to N-loss in the fermentor.

The second assumption seems the more probable, taking into account the high temperature in the fermentor and the strong ammonia odor of the outlet air. N-loss of 25% is not insignificant, and due attention should be paid to this problem. The final N-values determined in the baskets show that N was lost during composting in both variants. These losses, however, were slight: 3.1% in fresh refuse, and 4.6% in Multihum. If the N-balance had been based on the respective N-content of the dry substance (a procedure frequently adopted), a considerable N-increase would have been recorded (see Table 2). However, this basis of calculation is misleading here, just as it is in the calculation of losses of organic substance, because the C-loss leading to a decrease of the total mass is not taken into account.

The C/N-ratio (C calculated from the loss by ignition with the Factor 0.58) became narrower during composting and showed exceptional agreement in both variants, nothwithstanding the different digestion procedures.

The main objective of this preliminary experiment was to establish the extent of degradation of the material in the fermentor. To this end, the results obtained in the analysis of the fresh refuse must be taken as a basis. Moreover, it must be presumed that the material fed into the fermentor for at least three days preceding the experiment, originated from the same area and showed approximately the same composition.

Several late tests of samples taken straight from the conveyor belt at different times of the same day showed very different compositions, although originating from the same residential area. Conversely, the material produced by the fermentor and sampled at different times during one day proved to be exceptionally similar in composition. The heterogeneous character of the fresh refuse fed to the fermentor makes it impossible to give a final answer on the basis of a single preliminary analysis. A larger number of analyses is required, to allow statistical evaluation. On the other hand, comparison of the results showed a significantly lower temperature and CO -evolution during further digestion of Multihum in baskets, where the carbon losses of the readily decomposable fractions were also much lower. This infers unequivocally that a considerable degradation process takes place in the fermentor.

A certain indication of the character and intensity of this process — with the reservation of the possible error sources mentioned — is gained from the following comparative analysis of the fresh refuse and Multihum before the basket test was set up.

When the initial values obtained in the analysis of Multihum are compared with values of the same magnitude of the fresh refuse during composting in baskets, the intensity of digestion in the fermentor allows also for a comparative approximate estimation of the digestion in baskets to be expressed in time-units.

TABLE 3. Comparative losses in Multihum and fresh refuse after passage through the fermentor

	Fresh refuse (in relation to dry substance)	Multihum (in relation to dry substance)	% of loss in Multihum +)
Loss by ignition, in %	41.9	34.4	26,9
C % in Fraction I	1.58	0,94	46.8
C % in Fraction II	3.42	1,72	55,3
C % in Fraction III	4.37	4,20	14,4
Nitrogen, in %	0,64	0,54	25,0

+) in relation to 100 weight units of the fresh refuse

Digestion of individual components in the fermentor corresponds to the following number of days required for digestion in baskets:

Ignition loss, approx. 19 days	C% in Fraction I	approx. 4 – 6 days
	C% in Fraction II	approx. 32 days
CO_2 production, approx. 3 days	C% in Fraction III	approx. 4 days

It follows that digestion of certain components proceeded with considerably higher intensity in the fermentor, but never at a slower pace than in baskets. This is probably correlated with the specific conditions (aeration, turning, high temperatures) in the fermentor.

3. Microbiological examinations

In both materials the highest number of mesophilic bacteria was found in the beginning, and the lowest number at the end. Multihum contained in the beginning approx. 55% less germs than fresh refuse, which was probably the consequence of both high temperatures and reduced amount of soluble carbon compounds. At the same time, it is astounding that such a large number of mesophilic germs were able to resist temperatures of approx. 70°C.

The thermophilic bacteria were examined only while the high temperatures lasted. Their number was low in the minced material at the start, but increased, as expected, with the rise in temperatures. The opposite trend was recorded in Multihum. This was also to be expected, since the stage of maximum thermophilic digestion of this material had already taken place in the fermentor.

In both materials the trend of development of mesophilic cellulose decomposers and of acid and ammonia-producers was the same. The first group proliferated luxuriantly in the course of composting, whereas the population of the other groups steadily decreased. The only difference was that the number of cellulose decomposers, although initially of the same order in both materials, increased less in Multihum than in fresh refuse. It is not clear whether this should be attributed to some damage caused by the high temperatures in the fermentor or to a certain degradation of the cellulose. By contrast, the number of acid producers and ammonifiers was much higher in the fresh refuse, from the start, and the subsequent decrease was not so intensive.

These three physiological groups of microorganisms thus reveal interesting proportions. These were probably correlated with the nutrient material provided by the respective substrate, which in regard to character and quantity (as determined by chemical analysis) differed in the two materials and during the various

TABLE 4. Number of germs in millions per gram dry matter

Material	Composting in plastic baskets, in days	Max. temperature °C	Bacteria		Fungi		Cellulose decomposers 25°C	Acid producers 25°C	Ammonia producers 25°C
			mesophilic 25°C	thermophilic 55°C	mesophilic 25°C	thermophilic 48° C			
Fresh refuse	0	50	27,602	0.018	1.6	0.005	0.3	129	210
	6	27	6,030+)	2.2	10.3	3.0	0.2	99	29
	19	15	11,063	42.2	10.7	9.5	430.0	-	-
	56	12	5,053	-	30.3	-	160.0	61	15
	121		217	-	47.8	-	22,000.0	36	1.5
Multihum	0	36	12,060+)	325	-++)	0.001	0.3	29	9.3
	6	27	11,351	41	0.3	0.013	0.1	23	1.5
	19	15	7,538	28	8.7	0.004	54.0	-	-
	56	12	4,301	-	42.7	-	92.0	1	0.2
	121		249	-	54.3	-	92.0	0.3	0.08

+) This figure was obtained in a later examination since the plates could not be counted in the first test.
++) Discarded owing to contamination.

stages of digestion: The readily available organic substances were immediately vigorously attacked, and the corresponding flora was, therefore, highest in the beginning and lowest at the end of the process. The loss of C by predigestion in the fermentor was felt here, too, as reflected by the lower number of acid and ammonia producers. Conversely, the cellulolytic group increased in the course of further composting, so that the full value of the breakdown induced by these species could be estimated only at the end of about three weeks' composting. This was also in agreement with the chemical analyses. It is worth noting that in the fresh refuse the number of cellulolytic bacteria at the end of the process exceeded all other bacterial species. This proves again that total bacterial counts provide little information about the actual conditions. As the most important result of the microbiological examinations it should be noted that the development of the three physiological groups of bacteria proceeds parallelly with the degradation-sequence of the individual organic fractions. This phenomenon may possibly show the way to determine the dynamics of digestion by the biological determination of individual physiological groups, as in the case of mesophilic and thermophilic organisms.

The number of mesophilic fungi increased during composting in both materials. Qualitative examinations of the fungal flora established a significant increase of the cellulolytic species as digestion progressed. Since the amount of the difficultly decomposed cellulose was relatively increased after the rapid degradation of the readily soluble organic components, it may be assumed that proliferation of the fungi was mainly conditioned by the specific enrichment of the substrate with cellulose. In the beginning, the fungal counts were much lower in Multihum than in fresh refuse. This is explained by the unfavorable high temperature in the fermentor.

At the end of the composting the fungal number in both variants was about the same. The increase in Multihum was, therefore, relatively more pronounced. The increase of thermophilic fungi was more pronounced in fresh refuse than in Multihum, owing to the higher temperatures evolved.

4. Investigation of the effect on nitrogen conversion in soil

The Göttingen clayey soil used in the manuring experiment is known to be very fertile. The following was established upon analyzing it:

pH in KCl	7.2
Carbonate	4.5 %
Nitrogen	0.14%
C %	2.20

The results of the manuring experiment are summarized in Table 5.

Ammonia could be detected up to the 24th day of the experiment. In the main, the amount was less than 1 mg, and thus very little. The soil was therefore in a position to convert the ammonia rapidly. Nitrate formation showed the same trend in both materials:

1. The NO_3-content increased with time in all manuring variants as well as in the control;
2. The NO_3-content was the higher, the more prolonged the preceding composting was.

TABLE 5. Compost-manuring experiment in pots, at 25°C
Soil: Gottingen clayey loess Dose: corresponding to 100 t/ha

Manure	Composting time in plastic baskets, in days	Mineral nitrogen in soil after days (mg/100 g of dry substance)													
		4		14		24		34		50		78		160	
		NH_4	NO_3	NH_4	NO_3	NH_4	NO_3	NH_4	NO_3	NH_4	NO_3	NH_4	NO_3	NH_4	NO_3
Fresh refuse	0	0.73	5.73	0.12	0.73	0.37	1.21	0	1.83	0	4.27	0	10.98	0	19.77
	6	1.22	8.66	0.18	3.05	0.37	5.12	0	7.44	0	10.61	0	14.63	0	23.29
	19	0.73	9.76	0	12.68	0.25	14.27	0	20.49	0	31.83	0	25.61	0	33.74
	56	1.14	10.49	0	18.29	0.61	20.85	0	23.90	0	25.60	0	29.27	0	34.45
	121	1.55	11.10	0	20.85	0.25	25.24	0	27.56	0	29.26	0	32.93	0	35.44
Multihum	0	0.73	0.26	0	0.73	0.25	0.73	0	1.95	0	4.88	0	10.37	0	21.80
	6	0.79	7.20	0	0.97	0.18	3.05	0	4.88	0	8.66	0	10.98	0	26.83
	19	0.58	8.84	0	9.02	0.30	12.44	0	14.27	0	18.29	0	20.73	0	35.37
	56	0.88	11.83	0	18.29	0.25	20.85	0	22.93	0	24.88	0	24.39	0	35.37
	121	0.85	11.22	0	20.98	0.30	23.78	0	24.39	0	26.34	0	26.83	0	37.20
Without manure		1.40	8.29	0.24	16.95	0.49	20.00	0	20.98	0	23.05	0	24.51	0	26.52

The results obtained were as expected. A marked N-blockage was noticed in the beginning with samples of the fresh refuse composted for only 6 days. The blockage was still recorded (according to the control) after 160 days. Only samples composted for 56 days caused no N-blockage (with few insignificant exceptions).

In samples composted for 19 days the N-blockage disappeared in fresh refuse after 50 days, and in Multihum only after 160 days. It should be noted that up to the 78th day of the experiment less mineral nitrogen was detected in all Multihum variants than in the corresponding fresh refuse samples. The position changed only on the 160th day. Actually, an excess in the Multihum as against the fresh refuse might have been expected, owing to predigestion. The factors responsible for the opposite finding are not clear. The C/N ratio cannot be the cause since no significant difference existed between the two materials in this respect. Possibly, the Multihum contained less N (see Table 2).

As to the advantages of predigestion in the fermentor for the mineralization of nitrogen compounds in the soil, there seem to be none worth mentioning. Results show further that after excessive manuring with fresh material (100 or more tons during at least one growth period) there is a pronounced N-blockage, which in the absence of additional N-manure must lead to a marked depression of plant growth. Otherwise, this unripened compost should be applied for an adequate length of time before sowing or planting. In view of the results obtained it is especially worth noting that the N-blocking effect can be removed in compost within a shorter period of time than in soil.

5. Summary

a) Predigestion in the bactofermentor led to a relatively pronounced loss of C and N. The C-loss occurred mainly at the expense of the easily attacked organic compounds.

b) Degradation by predigestion was noticeable during subsequent composting in plastic baskets, mainly because of the lower temperature and CO_2 evolution in the Multihum than in the fresh refuse. The further rate of degradation, particularly of readily degraded carbohydrates, was conspicuously lower.

c) A close connection was established between the digestion process and bacterial development. The total bacterial flora as well as the number of acid and ammonia producers were highest at the time of the most intensive digestion. All three groups were better represented in the fresh refuse than in Multihum. Only the cellulolytic microorganisms increased in number during composting. Development of the individual groups thus proceeded parallel to the sequence of degradation of the corresponding fractions.

d) As expected, mineralization of N-compounds in the soil was the stronger the longer the composting period lasted; no advantages of the Multihum over fresh refuse could be traced. Fresh samples caused N-blockage, which was not entirely removed by the 160th day of composting.

Bibliography

Keller, P. Analyse und Bewertung der festen Abfälle mit Hinsicht auf deren Kompostierung (Analysis and Assessment of Solid Waste with Regard to its Composting). — Paper read at the 2nd Congress of I.A.M. in Essen, 1962 (duplicated).

Waksman, S.A. Z. Pflanzenernähr., Düng, Bodenkunde A 19, 1, 1931.

Balks, R. and I. Reekers. Bestimmung des Nitrat- und Ammoniakstickstoffs im Boden (Determination of Nitrate and Ammonia Nitrogen in the Soil). — Landwirtschaftliche Forschung 8, 7.

Kortleven, I. Diskussionsbeitrag (Contribution to the Discussion). — Informationsblatt der I.A.M. No. 10, 22. 1960.

AMINO ACIDS IN TECHNICAL AND BIOLOGICAL PROCESSING OF COMPOSTS

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The refuse of communal settlements contains in addition to an excess of carbohydrates, particularly cellulose, relatively small amounts of nitrogen bound in organic compounds occurring mostly in vegetal waste and food remnants, but also in rags, leather waste, straw, and other materials. The albumin content fluctuates according to the amount of organic constituents of the refuse and albumin-containing components of the latter.

In general, composting processes are directed to proceed in aerobic conditions; but the high amount of oxygen required by the decomposing mass frequently leads to the emergence of anaerobic zones in the collecting vessels. Albumin is readily broken down aerobically, whereby ammonia and amino acids split off by deamination. It seemed reasonable to study the effect of aeration on these reactions and, to this end, also to ascertain quantitatively the amino acids present in fresh refuse and in the composted material.

It is well known that household refuse varies according to the seasons and local conditions of the communal settlements. These interrelations have been thoroughly analyzed in the manual "Müll-und Abfallbeseitigung" (1). As established in this handbook, great fluctuations of all analytical values are to be expected; special attention should be paid to the representative average samples, irrespective of whether the sample is taken for evaluating the average refuse of a large community, or whether it is selected for laboratory preparation. Representative values of these small samples are the prerequisite for generalization on larger quantities. With the fluctuations of the refuse composition during the year and local specificities of the garbage, the analysis of a sample withdrawn at a certain time represents only the state at the respective time, so that sampling must be repeated several times in order to gain average values for every season.

The following analyses deal with the fresh refuse prepared in the Heidelberg plant during one day. It should be noted that household refuse was collected for several days before it was transported to the plant. The refuse analyzed originated from a large number of households; at the time of analysis (mid April) this refuse had been accumulating about a week. Microbial disintegration starts according to the temperature outside, either in the hauling trucks, or already in the household-garbage bin. By the time the refuse reaches the composting plant it is already more or less digested.

The minced fresh refuse was transported by trucks from Heidelberg to Braunschweig, where it was spread and dried as fast as possible. Preliminary portions of 12 kg each of the air-dried refuse were collected in paper bags from the carefully spread material. From these 12-kg portions of minced refuse (Dorr-screens with 22 – 35 mm perforations), samples of approximately 0.5 kg were withdrawn for analysis and milled.

The dry substance and total N of 30 such samples were determined. The amino acids were determined in eight of these samples of technically prepared minced refuse (not biologically processed compost), in order to obtain reference values for further examination of the composted material. The analyses of the amino acids in the minced fresh refuse were carried out in the course of three years (from 1959 till 1962).

Analytical procedure

The minced fresh material was first hydrolized with 6 N hydrochloric acid, at 116°C. The acid was then removed by vacuum distillation, and the residue dissolved in a buffer solution at pH 2.2, whereupon the amino acids were separated with the aid of a Beckman-Spinco analyzer.

Free, alcohol-soluble amino acids could not be detected either in the fresh minced material, or in the composted material. The amino acids were bound in the albumin. Although this finding could be expected in view of the great excess of carbohydrates (cellulose, etc.), it should not be generalized. The analysis of the amino acids was carried out in the chemistry laboratory (Director, Dr. Ing. Th. Breyhan) of our institute, by Mrs. Gertrud Jost.

The N-content (in % of dry substance) of 30 samples of minced material withdrawn in the course of composting amounted to 0.56 ± 0.009. The mean error of the average thus amounts to less than 2%, and shows surprisingly little variation of the N-content in the individual samples; the reliability of the results is based on the relatively large number of primary analyses.

The amino acids present in the minced material, as well as their amount in μmol/g minced material (dry substance) in eight different individual samples are summarized in the following table:

TABLE 1. Amino acids in hydrolyzed minced material (from Heidelberg)
μmol/g dry substance

	1	2	3	4	5	6	7	8	Mean value
Asparagine	12.00	12.30	12.28	13.00	10.50	13.10	10.30	12.45	12,0 ± 0,37
Threonine	4.60	5.00	5.96	6.40	4.50	5.60	4.95	5.35	5,3 ± 0,23
Serine	8.50	9.30	9.34	9.00	7.80	8.50	8.35	8.60	8,7 ± 0,18
Glutamine	14.90	16.90	19.30	17.40	15.80	17.30	15.50	16.85	16,7 ± 0,48
Proline	7.60	8.00	10.62	8.50	7.30	8.60	6.96	8.50	8,3 ± 0,40
Glycine	20.90	17.90	22.18	17.80	15.80	18.10	18.00	18.25	18,6 ± 0,70
Alanine	12.00	11.90	13.82	12.30	10.50	12.80	13.00	12.90	12,4 ± 0,17
Valine	3.40	3.50	4.59	4.10	3.40	4.00	3.45	3.50	3,7 ± 0,16
Methionine	+	+	0.64	0.50	1.00	1.20	0.75	1.00	0,9 ± 0,11
Isoleucine	2.20	2.70	3.48	2.80	2.60	3.00	2.45	2.75	2,7 ± 0,13
Leucine	6.90	7.60	8.80	7.70	6.50	7.80	6.55	7.40	7,4 ± 0,27
Tyrosine	0.80	0.90	1.73	1.00	1.30	1.30	0.96	1.60	1,2 ± 0,12
Phenylalanine	1.80	1.60	3.35	2.30	+	+	2.80	3.25	2,5 ± 0,30
Lysine	n.b.	n.b.	3.70	n.b.	+	2.70	2.80	2.70	3,0 ± 0,24
Histidine	n.b.	n.b.	1.42	n.b.	1.50	1.10	1.30	1.20	1,3 ± 0,07
Arginine	n.b.	n.b.	3.74	n.b.	3.30	3.10	3.40	3.30	3,4 ± 0,10
Tryptophane	n.b.	n.b.	n.b.	n.b.	0.80	0.70	0.80	0.80	0,8 ± 0,03

+ Qualitatively detected, but not determinable quantitatively

The dispersion of the 17 amino acids comprised in the eight samples is also slight. The + sign in Table 1 indicates that the automatic chromatography led to questionable numerical values. These analyses could not be taken into account in the calculation of the mean values. Dispersions were wider in Methionine, which is a sulfur containing readily splitting-off amino acid. Apart from Methionine, similar dispersions of Phenylalanine and Lysine were recorded. The mean error was high in Methionine, Phenylalanine and Tyrosine, in connection with which the rather small content of Tyrosine should be taken into account. The other amino acids show, in the main, a mean error of 4%. This low value indicates that the minced material of the eight portions of 0.5 kg each, or of 12 kg respectively, may be considered uniform. In the following analyses of amino acids in the biologically composted material the mean values listed in Table 1 are taken as the initial values.

The quantity of minced material as referred to dry substance (kg/drum) in thirthy 12-kg portions amounted to a mean of 11.5 ± 0.02 kg. Considering that the calculation is based on n = 30 analyses, the dispersion of the total amount calculated from the dry substance is far below 1%. This indicates that the preliminary sampling was performed conscientiously.

The minced material was composted under selective conditions (2). This is illustrated by four compost samples which, although withdrawn while thoroughly aerated (38 l air/kg refuse; 1.4 l air/minute/kg), could be differentiated by the water-content of the material (a — c) or by cutting out the oxygen and replacing it with nitrogen gas instead of air (d). Oxygen uptake drops with increased humidity, thus enabling differentiation of composts according to their properties which are clearly expressed by the amino acid content.

(Table 2, see next page)

Compared with the initial material (minced refuse from Heidelberg) composting at 30.5% humidity (Exp. 55/I) led to a 45% drop in the content of amino acids. The amino acids occurred approximately in the same proportions, apart from Methionine and Glycine which showed negligible differences. An increase in humidity to 34.6% (as against 30.5%) led only to diminished degradation of the amino acids, which in this case amounted to 24.7%. Since the drop of the total nitrogen was far less significant, transference of the nitrogen from the degraded amino acids to other nitrogen compounds was achieved. Release of nitrogen in the form of ammonia diminished with increased anaerobiosis and was slight according to the order of magnitude (< 0.5% of the total nitrogen). Further composting, or anaerobic composting (Exp. 57/II and Exp. 62/II), produced on the average almost the initial amounts of amino acids; in Exp. 57/II the positive and negative deviations are found within the dispersion of the values obtained in the analysis of the minced material. When the air-oxygen was completely cut out the loss in organic matter was rather low (3.5%), whereas the decrease in the amounts of Threonine, Serine, Glutamine and Leucine was more pronounced than in other amino acids. According to environmental conditions, determination may proceed along different patterns both aerobically and anaerobically. It should be taken into consideration that among the tabulated experiments only the last column (d) indicates strictly anaerobic conditions of composting. The compost obtained had the desired structure, was dark colored and exhaled the aromatic odor of organic acids or esters. After seven days hydrogen sulfide appeared, and at about the same time a certain amount of oxygen and a higher amount of carbon dioxide could be established in the residual gases. Gerretsen (3) reported considerable amounts of oxygen in a far-gone anaerobic stock of a 9-month old compost, in Wijster, which could not be explained. The data summarized in Table 3 might give some indications for further investigation.

TABLE 2. Amino acids in biologically processed hydrolyzed compost (in absolute and relative values)

	Minced fresh material	Exp 55/I a		Exp 56/II b		Exp 57/I c		Exp 62/II d	
Duration of experiment (days)	-	10		10		10		10	
Initial organic mass (%)	30.6 ± 0.18	32.7		30.3		31.1		30.0	
Organic mass after 10 days	-	26.5		27.2		27.0		29.8	
Initial H_2O%	-	30.5		34.6		39.8		45.3	
H_2O% after 10 days	-	29.5		35.2		40.9		45.6	
Water quotient after 10 days	-	1.12		1.30		1.51		1.53	
NH_3 in 10 days in each drum (mg N)	-	316.8		207.8		81.3		17.1	
Amino acids	μmol/g	μmol/g	rel.	μmol/g	rel.	μmol/g	rel.	μmol/g	rel.
Asparagine	12.0 ± 0.37	6.73	56.1	9.77	81.4	12.91	107.6	11.62	96.8
Threonine	5.3 ± 0.23	2.27	42.8	3.77	71.1	4.65	87.7	4.33	81.7
Serine	8.7 ± 0.18	4.49	51.6	6.39	73.5	7.39	84.9	6.84	78.6
Glutamine	16.7 ± 0.48	8.14	48.7	11.29	67.6	13.90	83.2	13.52	81.0
Proline	8.3 ± 0.40	4.32	52.0	5.99	72.2	8.07	97.2	7.57	91.2
Glycine	18.6 ± 0.70	12.32	66.32	13.38	71.9	16.26	87.4	17.65	94.9
Alanine	12.4 ± 0.17	7.23	58.3	8.49	68.5	10.35	83.5	11.70	94.4
Valine	3.7 ± 0.16	1.90	51.4	3.12	84.3	4.15	112.0	3.36	90.8
Methionine	0.85 ± 0.11	0.71	83.5	0.69	81.2	1.08	127.1	0.95	111.6
Isoleucine	2.7 ± 0.13	1.20	44.4	2.10	77.8	2.94	108.9	2.15	79.6
Leucine	7.4 ± 0.27	3.54	47.8	5.87	79.3	7.24	97.8	5.84	78.9
	100		54.8		75.3		97.9		89.0

Appoximately the same amounts of CO_2 were recorded in the exhaust gases of anaerobic digestion as in the aerated composts. (Mean of Exp 62/I and II: 9.60 vol %; mean of Exp 55/I and 57/I: 10.14 vol %). The oxygen released during the first few days in experiments 62/I and 62/II can be traced back to the air introduced when filling the drums. On the 8th day the amount of CO_2 released increased, while at the same time oxygen and hydrogen sulfide evolved in anaerobic conditions.

Nevertheless, as evident from experiments 62/II and 57/I, the content of Methionine increased in anaerobic conditions as against the amount found in experiments 55/I and 56/I, and in the initial material.

TABLE 3 CO_2, O_2 and H_2S in the gases evolved (vol.%)

Day	Exp 62/I with N_2 (40 % H_2O)			Exp 62/II with N_2 (45 % H_2O)			Exp 57/I (40 % H_2O)			Exp 55/I (30,5% H_2O)		
	CO_2	O_2	H_2S	CO_2	O_2	H_2S	CO_2	O_2	H_2S	CO_2	O_2	H_2S
1	12.96	0.15	-	13.12	0.17	-	8.79	10.88	-	8.80	10.11	-
2	16.54	0.12	-	18.80	0.17	-	11.47	10.76	-	8.84	10.31	-
3	15.93	0.13	-	15.09	-	-	10.12	11.10	-	9.40	10.02	-
4	9.18	-	-	9.90	-	-	7.34	11.26	-	10.18	8.13	-
5	6.54	-	-	6.54	-	-	8.31	10.58	-	10.94	7.73	-
6	5.32	-	-	5.19	-	-	10.64	9.48	-	11.55	6.64	-
7	3.93	-	+	6.90	-	+	14.32	7.98	-	11.66	7.09	-
8	8.24	0.72	+++	9.56	0.18	+++	12.21	8.64	-	10.38	8.03	-
9	6.85	-	++	7.95	-	++	10.34	9.20	-	9.90	8.69	-
10	6.65	-	-	6.85	-	-	8.87	9.88	-	8.62	10.12	-
Compost, almost odorless				acrid, aromatic			slightly fetid, intensely musty			odorless		
H_2O - quotient after 10 days:	1.41			1.53			1.51			1.12		
In the beginning:	1.36			1.51			1.28			0.94		
Loss of organic mass:	7.4%			3.5%			18.2%			22.5%		

In fresh refuse sulfur may occur in anorganic form (sulfate salts), or elemental flower of sulfur. The organic sulfur compounds in vegetal material are oxygen-free (amino acids, mustard oils). It is assumed therefore that the oxidized anorganic sulfur compounds were reduced to hydrogen-sulfide, whereby apart from the oxygen utilized by microbial activity, some of the gaseous oxygen was carried away with the nitrogen flow (N_2). In the anaerobically gained composts the amount of Methionine increased. The reduction of sulfates to hydrogen sulfide is a widespread occurrence in anaerobic processing of organic fertilizers.

Summary

1) The refuse obtained from Heidelberg, technically prepared in a grinding-sifting installation (Dorr-Oliver), was used in experimental composting, in the course of which the initial material (minced fresh refuse), as well as the biologically prepared compost were used for the determination of bound amino acids. Free amino acids could not be traced in any of the composts prepared.

2) Special attention was paid to withdrawal of representative samples of 0.5 kg each of minced material from approx. 1,000 kg refuse. The dispersion values obtained showed that correct sampling was achieved.

The dry mass of the corresponding 12 kg air-dried refuse amounted to 11.50 ± ± 0.02 kg; accordingly, the mean error in relation to the measured value was 0.18%.

The mean value of the nitrogen content (determined by Kjeldahl) of the minced material amounted to 0.56 ± 0.009% (n = 30 analyses). From this the mean error was calculated as being 1.60%. The great majority of amino acids in the minced material showed a mean error of 4% (n = 8 analyses). Greater deviations of Methionine (about 12%), Tyrosine (10%) and Phenylalanine (12%) were recorded in minced material, in which these amino acids occur in relatively low concentrations.

3) In 10-day old biological preparations the reduction in the amount of amino acids was insignificant when further degradation proceeded anaerobically. Small amounts of split-off ammonia carried away with the gas flow served as indicators (Experiments c and d); with further aerobic processing (Experiment a), about 45% of the amino acids were quantitatively converted into other compounds, or released in gaseous form. The release of ammonia indicated with certainty the amount of oxygen available in composting processes of short duration, but the total amount of ammonia released was not very large.

4) At the end of the strictly anaerobic composting both oxygen and hydrogen sulfides were revealed in small amounts.

Bibliography

Jäger, B. Müll und Abfallbeseitigung (Waste and Refuse Disposal). – In: Kumpf, W., K. Maas, H. Straub (Editors). Handbuch über Sammlung, Beseitigung und Verwertung von Abfällen aus Haushaltungen, Gemeinden und Wirtschaft. Berlin, Erich Schmidt-Verlag, 1964.

Sauerlandt, W., and L. Müller. Ein Beitrag zur Kompostierung von Müll in Drehtrommeln (Contribution on the Subject of Composting Refuse in Rotary Drums). – Forschung und Beratung (Düsseldorf) Reihe C, No. 4. 1962.

Gerretsen, F.C. Einige Untersuchungen über wichtige Probleme der Stadtmüllkompostierung in Holland (Some Investigations Concerning Important Problems of Composting Town Refuse in Holland). – Vorträge der Arbeitstagung der AkA in Düsseldorf, pp. 90 – 96. 1957.

ENZYMATIC ACTIVITY AND DEGRADATION OF MATTER IN REFUSE DIGESTION; SUGGESTED NEW METHOD FOR MICROBIOLOGICAL DETERMINATION OF THE DEGREE OF DIGESTION

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Chemical and physical methods have been used for some time in the examination and estimation of the reactions taking place in the course of refuse digestion. The procedures collected in the Instruction Sheets of the VKF (1964) and in the Collection of Methods of IAM (1965) are among the most widely adopted. With their aid, data of high accuracy can be obtained on the content of C, N, P, K, Mg, total and active or decomposable organic substances, cellulose, and toxic compounds; also on water content, pH-values, conductivity and caloric values.

These determinations encompass some of the most important factors in the process of digestion, but not all of them. A more complete characterization was therefore attempted with the aid of biological tests in order to establish, if possible the "degree of ripeness." So far, two methods of this kind were applied; determination of the number of microorganisms, and self-heating (after Niese, 1963, simplified in the Merkblätter [Notes] of VKF, 196, M 6, p. 11). The latter procedure makes it possible to determine any digestion-blocking components, and thus to determine also the composting compatibility of the refuse. From the scientific point of view these methods are not satisfactory inasmuch as they determine the total effect of a number of greatly varying factors some of which may have opposite effects. They are useful, however, for routine work, although in many cases they prove to be too exacting. Hence, it would be desirable to develop simpler procedures that will assist in recording biological processes as specifically and as accurately as possible.

To this end, the modern methods of enzyme-determination appear to be the most indicated, particularly those adopted in soil science and sewage purification. Therefore, we have tentatively applied these methods in experimental composting of small heaps of minced household refuse, in order to find out to what extent the results obtained correspond to the degradation and "digestion, or ripeness" of the material. The enzymes determined were dehydrogenase, phosphatase and cellulase. Since determination of dehydrogenase with trinitrophenyltetrazolium (TTC) has proved unsatisfactory, owing to the inadequate and widely dispersed values, the method has been abandoned. Phosphatase, like dehydrogenase, also serves as a general indicator of microbial activity, for this enzyme reflects the energy balance of all microorganisms. Cellulase determination should assist in tracing the degradation of the most important single substance, cellulose. In this case we deal with an adaptive enzyme that occurs only in certain microorganisms. The extent of degradation of the total organic matter (TOM) was determined by the loss through ignition. Finally, a fungal growth test was developed for demonstration of the degradation even of small quantities of nutrient sources, especially of cellulose, and for determination of the "ripeness point."

Material and Methods

Composting

Conical heaps, 1.2 m high, of freshly minced household refuse, from the refuse-reclamation plant at Küsnacht (Zurich) were set up in the open, in autumn. This refuse is rich in paper and poor in ash (its content of organic matter exceeding 60%); it was mixed with digested sewage sludge so as to attain a final water content of more than 55%. The refuse was minced in Buhler hammer mills (coarse and fine mills), whereas homogenization, mixing with sludge and final sifting were carried out in a Dano-Egsetor, having a screen with 15 mm perforations. The material was turned over manually with shovels, at least once a fortnight throughout the period of composting, and the water content maintained at 40%. The temperature was recorded regularly at depths of 20 and 50 cm below the tip of the cone.

Sampling and sample preparation

Small portions of compost were withdrawn weekly from different parts of the pile to form a mixed sample of 2 – 3 kg, which was immediately spread in thin layers on tin trays in an aerated drying oven at 25°C, and dried to constant weight.

From this material samples weighing from 300 to 600 g were comminuted in ball mills of 6 l capacity containing iron balls ten times the sample weight, and operated at a speed of 50 r.p.m.(samples intended for enzyme determinations were comminuted for 20 minutes; for other analyses – three hours). The samples thus pulverized were placed in glass jars and stored in a dry room.

Phosphatase determination

Hofmann' s method (1963) was adopted with minor modifications. Accordingly, at pH 9.6, phenol is split off from disodiumphenyl phosphate; when treated with 2,6-dibromquinonchlorimide the phenol passes into a blue dye and is colorimetrically determined.

Reagents:

1. **Substrate solution:** 6.75 g disodiumphenyl phosphate C.P. ($C_6H_5OPO_3Na_2 \cdot H_2O$, molecular weight 236.08) are dissolved in one liter distilled water. 1 ml corresponds to 25 mg phenol
2. **Buffer solution:**
   a) acetate buffer pH 5.0, see Hofmann (1963)
   b) citrate buffer pH 7.0; 300 g tertiary potassium citrate pure ($K_3C_6H_5O_7 + H_2O$) is dissolved in about 700 ml water, adjusted with the aid of a glass electrode to pH 7.0 by addition of 20% NaOH and diluted HCl, and made up to 1.0 l.
   c) borate buffer pH 9.6; 56.85 g borax · 10 H_2O is dissolved under moderate heating in about 1.5 l water, adjusted after cooling to pH 9.6 (electrometrically) with NaOH 20%, and the volume made up to 2.0 l.
3. **Dye:**
   200 mg dibromquinone-4-chlorimide C.P. are dissolved in 100 ml ethanol.
4. **Standard solution:**
   a) **Stock solution:** 1.0 g phenol C.P. (stored in desiccator) is dissolved in 1.0 l distilled water. This solution keeps quite a long time if stored in brown bottles.
   b) **Working solution:** 10 ml of stock solution are diluted with distilled water to 1.0 l; 1.0 ml of the working solution then corresponds to 10 γ phenol.

Of the sample dried at 25°C and comminuted for 20 minutes, 2 g are mixed with 1.5 ml toluol, in a 100-ml cylinder fitted with a ground-glasstopper. After 15 minutes, 20 ml substrate solution and 20 ml buffer solution 2 b are added; the mixture is shaken, stoppered and kept for 3 hours at 37°C. The volume is then brought to 100 ml with distilled water of about 38°C, and immediately centrifuged for 30 min. at 3,000 r.p.m. For each sample a control consisting of 20 ml water and 20 ml buffer solution is set up. In our experiments each sample was run in duplicate, and both were set up at the same time.

To 100-ml volumetric flasks containing 5 ml buffer solution 2 c, 1.0 ml of the centrifugate and 50 ml distilled water are added under continuous shaking and colored with 1 ml of freshly prepared dye solution. Maximum intensity of coloration is attained after 20 minutes. The volume is then made up to 100 ml. and determination is carried out within 3 hours with the aid of a colorimeter, at 630 mμ, and a layer 1.0 cm thick. The standard curve is plotted from 1 – 25-ml samples of the phenol working solution prepared in the same way and determined with each series. The curve corresponds to concentrations ranging from 10 to 250 γ phenol. The readings of the samples minus those of the control, both expressed in γ phenol, give the number of phosphatase in the sample. This number can also be converted into grams of organic matter, determined as loss by ignition, or into grams of decomposable organic matter (DOM).

Cellulase determination

Determination is based on the principle formulated by Hanstein (1960) and Schaefer (1957), according to which cellulase activity is assessed from the decrease of viscosity of a carboxymethyl cellulose solution. The capillary tube viscometer after Ubbeholde was used, since it proved adequately accurate and handy.

In a 1,500 ml glass beaker 20 g sodium carboxymethyl cellulose (CMC medium viscosity) are gradually added to 750 ml aqua dest. The suspension is dissolved in a water-bath at 100°C with the aid of an electrical stirrer until clear; this may require several hours. The solution is then transferred to a 1,000 ml volumetric flask and placed for 12 hours in a drying oven at 50°C. The next day, after cooling to 20°C the flask is filled to the mark with distilled water. At the same time, 6.89 NaOH, and 14.7 g citric acid are dissolved in a little distilled water, transferred to a 1,000 ml volumetric flask and filled to the mark with aqua dest. The CMC-and buffer solutions are then mixed, well shaken and filtered through a thoroughly cleaned glassfilter, Jena 17 G 2. This substrate solution may be stored for several months at 4°C.

From the sample dried at 25°C and comminuted for 20 minutes, 10 g are introduced in a 500 ml Erlenmeyer flask containing 100 ml distilled water, placed in a shaker for 20 minutes, and finally centrifuged twice within 20 minutes, at 3,000 r.p.m. From the supernatant refuse-extract 1.0 ml is added to 19.0 ml of substrate solution in a 50 ml flask with a ground glass stopper, thoroughly shaken, stoppered and incubated for 15 hours at 50°C. At the end of this time a mixture of 19.0 ml substrate solution with 1.0 ml aqua dest. is prepared for control, and measured immediately in the viscometer, at 20°C. The refuse-extract samples are then measured in the same conditions. Since maintenance of constant temperature is of utmost importance in viscosity measurements, the mixtures to be examined are kept for 20 minutes before determination and throughout the operation in the ultra-thermostat, where temperature fluctuations are less than ± 0.05°C at 20.0°C.

Cellulase activity is calculated in percentages of viscosity decrease as follows:

$$\%\ \text{viscosity} = \frac{t_o - t_{15}}{t_o} \cdot 100$$

t_o = time of flow of control

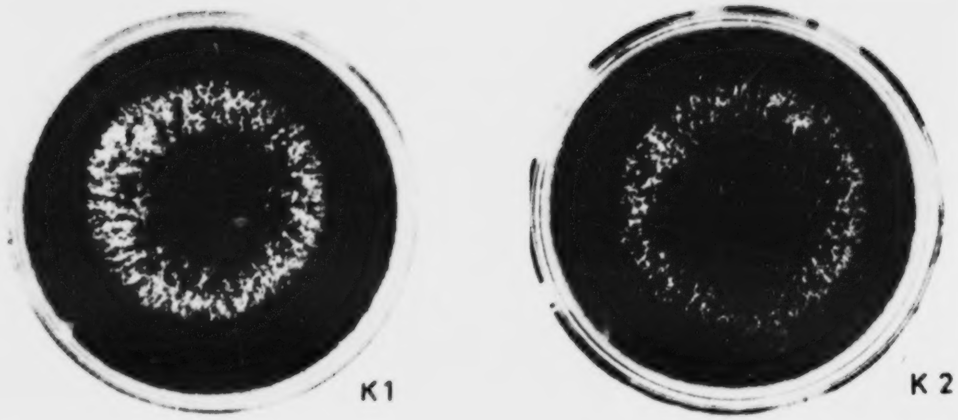
t_{15} = time of flow of test sample after 15-hours' incubation

The time of flow is measured at least five consecutive times and an average value is thus obtained. Also, 2 – 3 replicas of the test sample are measured.

Fungal-growth test with Chaetomium gracile Udagawa

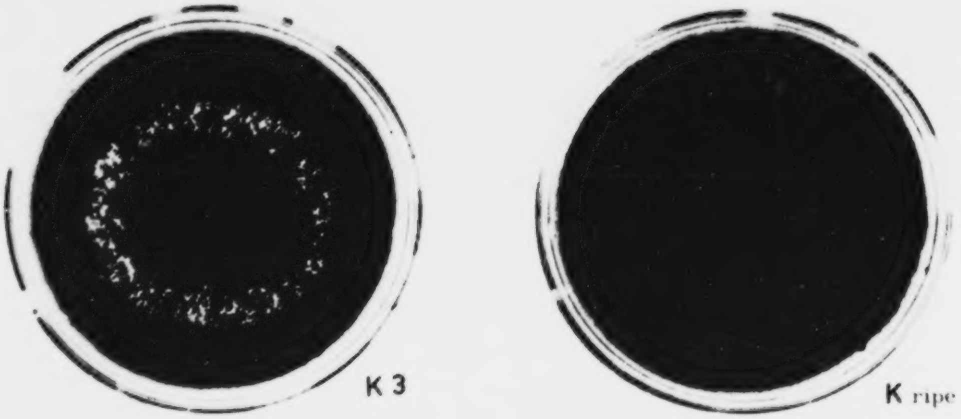
Suggested new method for biological determination of the degree of digestion

Principle: The growth and formation of fruiting bodies of a Chaetomium gracile strain are measured on a solid nutrient medium containing pulverized refuse of compost (EAWAG No. 31)



C 1. Fresh refuse

C 2. Composted one week



C 3. Composted two weeks

C ripe. Ripe compost

FIGURE 1. *Chaetomium* test, 5-day old cultures.

The strain used in the test was isolated from refuse and is thermotolerant. The closely related species *Chaetomium globosum* is known for its cellulolytic properties (Agarwal et al., 1963).

Composition of nutrient medium:

KH_2PO_4	1.0 g
$MgSO_4 \cdot 7\,H_2O$	0.5 g
$Na\,NO_3$	0.5 g
NH_4NO_3	1.0 g
$K\,Cl$	0.5 g
$FeSO_4 \cdot 7\,H_2O$	trace
A – Z solution (trace elements)	1.0 ml
Difco Agar	18.0 g
Refuse (dry and pulverized)	10.0 g
Aqua dest.	1000 ml

The trace-elements solution contains in 1.0 l distilled H_2O:

600 mg	H_3BO_3
400 mg	$MnCl_2 \cdot 4\,H_2O$
55 mg	$CuSO_4 \cdot 5\,H_2O$
55 mg	$ZnSO_4 \cdot 7\,H_2O$
55 mg	$Al_2(SO_4)_3 \cdot 18\,H_2O$
55 mg	$NiSO_4 \cdot 7\,H_2O$
55 mg	$Co(NO_3)_2 \cdot 6\,H_2O$
55 mg	$Ti\,O_2$
28 mg	$Mo\,O_3$
28 mg	$Li\,Cl$
28 mg	$SnCl_2 \cdot 2\,H_2O$
28 mg	$K\,J$
28 mg	$K\,Br$

The refuse admixed with the medium should be thoroughly dried (at 25 or 105°C until constant weight is attained), and milled for at least 3 hours in a ball mill. Of the autoclaved medium (20 minutes at 120°C) 25 ml are poured in sterile conditions into Petri dishes (15 × 100 mm). When this becomes solidified, a small mycelial clump of the test organism (Chaetomium gracile) is placed in the center of each agar plate. The plates are incubated at 37°C, since according to Agarwal et al. (1963) enzymatic activity is highest at this temperature. The substrate mycelium covers the plates to the rim within 4 – 5 days, whereas the aerial mycelium develops only on samples that have not reached an advanced state of digestion (Figure 1).

After 12 days the fruiting bodies on the agar surface, where formed, are counted with the aid of a binocular magnifying lens.

Results

The results obtained in two series of experiments are graphically presented in Figures 2 and 3. Apart from the phosphatase activity both curves during the first seven weeks reveal highest activity which later drops to lower, rather stationary values (compare also with Braun, 1964). The curves of the total and decomposable organic matter given in percent of the corresponding initial weight of the dry material (% IDM), show unequivocally that in this experimental setup the actual measurable degradation of the material is completed at the end of 7 to 8 weeks. The intensive digestion process with the breakdown of the readily degraded compounds is ended, while gradual humification and mineralization continues.

The Chaetomium test indicates that degradation is not complete. Up to the fourth week of composting the degree of degradation can only be estimated from the continuously decreasing rate of aerial-mycelium formation (Figure 1), while fruiting-bodies are so intensively produced that their counting proves rather tedious. After the so-called "ripeness point" is attained (in our experiments, after 7 – 8 weeks), the values obtained show only slight changes, with both the chemical and enzymatic-biological methods, whereas the number of fruiting-bodies

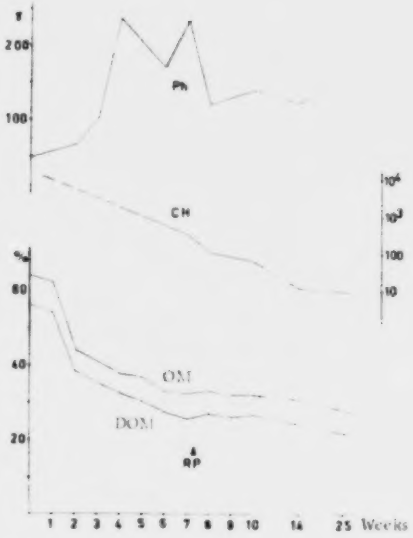


FIGURE 2. Course of digestion, series A
Abscissa: Composting time in weeks
Ordinate: Ph Phosphatase, γ phenol per g DOM
CH Chaetomium test, number fruiting bodies/plate
OM - Organic matter (loss by ignition)°
DOM = Decomposable organic matter°
° in % of the initial dry material

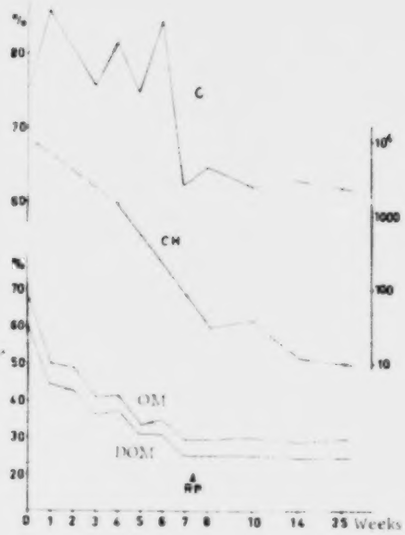


FIGURE 3. Course of digestion series B
Abscissa: Composting time in weeks
Ordinate: C - Cellulase, % of decrease of viscos.
CH = Chaetomium test, number of fruiting bodies/plate
OM - Organic matter (loss by ignition)°
DOM = Decomposable organic matter°
° in % of the initial dry material

produced after 12 days may continue to decrease for some time until a minimum is reached here, too (Figures 2 and 3).

While the composition of the initial material may lead to wide fluctuations of the values of OM, DOM and enzymatic activity, the values obtained by the Chaetomium test seem to be relatively independent of the material used. This is evident also from the values listed in Table 1, obtained in the analysis of composts from different Swiss composting plants.

Discussion

The results obtained so far cannot as yet lead to definite conclusions in regard to the values of the enzymatic and biological testing procedures. Nevertheless, it seems possible to characterize the microbial activity in the same way as with the currently used methods of microbial counts and self-heating capacity, while the testing procedure is simpler and less demanding in equipment. The cellulase determination and the Chaetomium test produce additional data on the specific processes of degradation. For the purpose of preliminary analysis, the quite simple yet accurate determinations of the total and decomposable organic matter (OM, DOM), or group analysis (Glathe et al. 1964) are quite adequate, since according to our experiments stationary, or slightly diminishing, values are obtained from a certain point onward with all the methods used (with the exception of phosphatase determination). This point, attained in our work after 7 – 8 weeks,

TABLE 1.

Composting plant	Age in months	OM	DOM	CH
Hinwil	from biostabil.	47.9	40.7	>5,000
	from biostabil.	54.5	45.6	>3,000
	from biostabil.	53.4	44.4	>3,000
	2	40.2	32.3	380
	4	40.8	34.1	920
	4	44.5	33.2	100
	5	45.1	37.9	110
	6	45.4	41.3	440
	6	46.6	39.4	110
	6	43.7	37.5	110
	9	46.2	39.7	35
	9	33.5	18.5	300
	10	31.3	20.3	110
Buchs	6	30.4	12.8	65
Kusnacht	6	51.8	45.6	650
	7	55.2	47.6	550
	12	48.1	42.3	50
	18	40.7	30.6	3
Olten	3	38.3	26.7	1,300

OM = total organic matter (loss by ignition)
DOM = decomposable organic matter
CH = Chaetomium-test

may indicate the "ripeness point" of readily decomposable matter; it can be established directly with the OM and DOM determinations.

These tests, however, require examination at regular intervals throughout the digestion process, because the values obtained at the "ripeness point" may vary considerably, depending upon the composition of the initial material. Thus, the total OM of refuse rich in paper, expressed in percent of initial dry material (% IDM), amounts to more than 30, whereas for refuse rich in ash it may be much lower. These examinations are, therefore, too demanding to be adopted in the routine work of composting plants. Single spot tests would be indicated for the latter. This seems to be possible only with the Chaetomium test. The results obtained show that quite definite values can be obtained at the "ripeness point" irrespective of the composition of the initial material, and that these values decrease with further digestion beyond the "ripeness point." Chaetomium-test values below 300 indicate the degree of digestion at the "point of ripeness" or beyond it. Material of that kind can unhesitatingly be regarded as ripe compost. Nevertheless, further examinations should establish if this is compatible with the various kinds of composts, and whether the values obtained are determined solely by the content of organic nutrient matter, or also by other active factors, such as inhibitory substances.

The curve of cellulase activity drops from the "ripeness point" to lower, stationary values. The essential part of cellulose degradation is thus achieved. We were interested, however, to find out under what conditions this degradation proceeds most intensively. To this end, the activity was determined in the different layers of a refuse-sewage-sludge compost heap at the Küsnacht-Zurich plant, at the second turning of the material, after 10 weeks of digestion. The heap was more than 2 m high. Three samples were withdrawn for cellulase determination from the following layers:

		Water content	OM	DOM	Cellulase
Fungal zone	20−30 cm deep	56.1	53.1	47.6	87.7
Central zone	100 cm deep	57.1	58.8	56.2	9.7
Bottom zone	200 cm deep	56.2	56.0	50.8	14.8

It was revealed that the activity was most intensive in the so-called "fungal layer," which was exceedingly rich in fungi, although still well aerated and yet self heated. Accordingly, degradation of cellulose is maximal under these conditions, and this explains the excessive fungal growth in the lower, well aerated compost heaps.

Summary

Determination of cellulase and phosphatase activity in the course of composting is described. These enzyme analyses furnish a certain evaluation of the microbial activity, provided examinations are regularly performed throughout the process of digestion. The chemical analysis, especially determination of the total and decomposable organic matter, presents under similar conditions a reliable measure of the extent of degradation, and is instrumental in establishing a "ripeness point" that indicates the end of the intensive degradation processes. With the biological Cheatomium test, as described above, the same is attained with single examinations, since the values obtained from household refuse in this case do not depend upon the components of the refuse. This test, therefore, appears to be suitable for the control of composting processes of household refuse when absolutely ripe compost is specifically required.

We are indebted to Dr. E. Müller (Department of Special Botanics of the Federal Technical Institute) for the identification of the Chaetomium species, and to Miss E. Zimmermann, for her valuable cooperation.

Bibliography

Agarwal, P.N., G.M. Verma, R.K. Verma, and D.D. Sahgal. Decomposition of Cellulose by the Fungus Chaetomium globosum. I. Studies on enzyme activity. — Indian J. Exp. Biol., Vol. 1, pp. 46 — 50. 1963.

Braun, R. Möglichkeiten der biologischen Behandlung von festen Abfallstoffen (Possibilities of Biological Treatment of Solid Waste). — Schweiz. Z. Hydrol. Vol. 26, No. 2. 1964.

Glathe, H., G. Farkasdi, G. Niese, A. v. Klopotek and E. Ahrens. Beiträge zur Biologie des Brikollare-Verfahrens (Contributions to the Biology of the Brikollare Process). — Städtehygiene, Vol. 15, No. 7, pp. 150 — 155. 1964

Hanstein, E. Untersuchungen über die celluloseabbauenden Enzyme von Irpex lacteus Fr. und Trichoderma viride Pers. ex. Fr. (Investigations of the Cellulose Decomposing Enzymes in Irpex lacteus Fr. and Trichoderma viride Pers. ex. Fr.). — Ber. Schweiz. Bot. Ges., Vol. 70, pp. 314 — 351. 1960.

Hofmann, E. Die Analyse von Enzymen im Boden (Analysis of Enzymes in Soil). — In: Linskens H.F. and M.V. Tracey "Moderne Methoden der Pflanzenanalyse," Vol. 6, pp. 416 — 423. 1963.

I. A. M. Internationale Arbeitsgemeinschaft für Müllforschung. Methoden zur Untersuchung von Müll- und Müllklärschlamm-Kompost (Methods of Investigating Refuse and Sewage Sludge Compost). — Zurich. Sekretariat der I. A. M. (in press).

Niese, G. Versuche zur Bestimmung des Rottegrades von Müllkomposten mit Hilfe der Selbsterhitzungsfähigkeit (Experiments in Determining the Degree of Decomposition of Refuse Compost Due to Self-Heating Ability). — Informaionsblatt der I. A. M., No. 17, pp. 2 — 14. 1963.

Rollé, G. and B. Orsanic. Eine neue Methode zur Bestimmung der abbaubaren und der resistenten organischen Substanz in Müll und Müllkomposten (A New Method of Determining Decomposable and Resistant Organic Matter in Refuse and Refuse Composts). — Informationsblatt der I. A. M. No. 21, pp. 3 — 13. 1964.

Schaefer, A.C. Ueber die Bildung und Wirkung eines zellulosespaltenden Fermentes aus Schimmelpilzen (On the Formation and Effect of a Cellulose Splitting Ferment in Molds). — Bericht Schweiz. Botanische Gesellschaft, Vol. 67, pp. 218 — 270. 1957.

VKF Verband kommunaler Fuhrparkbetriebe (Association of Communal Vehicle Fleets). Merkblätter des VKF (Notes of VKF). — M 1 to M 6, Draft. September 1964.

ANNOUNCEMENTS OF THE SECRETARIAT

The Information Bulletin announces the publication of a new column under the heading "Communications from Industry"

In recent years industrial firms have repeatedly approached us with the request to insert advertisements in our Bulletin. We were unable to comply with this request because the offset print of our publication is unsuitable for this purpose.

However, in order to provide an opportunity for the industries connected with the reclamation and disposal of solid waste to express their views in this specific organ, the I. A. M. executive has decided to introduce a special column in the Bulletin under the heading "Communications from Industry." In this way the firms will be able to inform our readers of new technical developments, modern refuse reclamation plants, special machinery for refuse processing, reports on the results achieved with their products, etc. For the time being this information will appear in the French and German editions only.

These contributions, which may be accompanied by illustrations, should be written in a matter-of-fact and incontroversial style and be of general interest. The I. A. M. Secretariat reserves the right to withhold publication of contributions.

Proceedings of the III International Congress of IAM in Trento

A limited number of copies of the volume of lectures and debates at the Congress is still available in German, French, English and Italian, and can be obtained from Segretario del Congresso GISRUS, Sign. G. Grassi, Via Belenzani 3, Trento (Italy). Price: Lit. 7,500.

This volume of 350 pages presents in detail the subjects dealt with in short abstracts at the Congress. It contains 129 illustrations, including color plates and numerous tables.

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Ellis, H. M. Beeinflussung der ober- und unterirdischen Gewasser durch Ablagerung fester Abfallstoffe; Forschungen und Erfahrungen in Grossbritannien (Effect of Solid Waste Decomposition on Surface Water and Groundwater; Research and Experiences in Great Britain).

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Wuhrmann, K. Möglichkeiten und Grenzen der verschiedenen Abfallbeseitigungsverfahren (Possibilities and Limitations of Different Waste Disposal Procedures).

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Schwarz, K. Massnahmen zur Reinhaltung der Luft bei Müllverbrennungsanlagen (Measures of Air Pollution Control Around Waste Incineration Plants).

Chovin, P. Untersuchungen über die Staubniederschläge in der Umgebung einer Müllverbrennungsanlage (Investigations of Dust Precipitation in the Vicinity of a Waste Incineration Plant).

Riedel, E. O. Ueber die Nützlichkeit des mechanischen Zerkleinerns und Siebens von Abfällen (The Usefulness of Mechanical Comminution and Screening of Refuse).

Erbel, A. Zur physikalischen Aufbereitung des Hausmülls (The Physical Processing of Domestic Refuse).

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Teensma, B. Die Bedeutung der Vorverrottung bei der Kompostierung (The Importance of Preliminary Digestion in Composting).

Maystre, Y. Das Geruchsproblem bei der Kompostierung (The Problem of Odor in Composting).

Braun, R. Das Klärschlamm-Problem (The Problem of Sewage Sludge).

Mendia, L. Das Klärschlamm-Problem in Italien (Dieser Beitrag ist nur in der italienischen Fassung enthalten) (The Problem of Sewage Sludge in Italy) (This Contribution is available only in Italian).

de Fraja Frangipane, E. Stand und zukünftige Entwicklung der Abfallbeseitigung in Italien (Present State and Future Development of Waste Disposal in Italy).

INFORMATION BULLETIN NUMBER 25
December 1965

COMPOSTING DEVELOPMENTS IN THE UNITED STATES

By John S. Wiley and O.W.Kochtitzky, Chattanooga, Tennessee

Quantities of municipal refuse in the United States continue to increase at an alarming rate due primarily to two factors: population increase and per capita increase in refuse production. Total refuse production is expected to double by 1985, and the population will double by the year 2,000. Individual refuse production is now estimated at about 4.5 lb/cap/day.[1] Most of the population growth is expected to occur in our cities and their surrounding urbanized areas. This will greatly reduce the available land area within economical haul distances for the ultimate disposal of refuse.

The increase in volume of refuse is far greater than the increase in weight; refuse is becoming more bulky and less dense. The biggest increase in refuse production is in low-density combustible rubbish, primarily paper and plastics. Small reductions are continuing to occur in the heavier refuse classes of garbage and ashes.

Many cities now using open dumps or landfills will have to resort to some method of volume reduction to conserve land areas for long-term refuse disposal. Volume reduction may be achieved by various types of individual on-site disposal methods, such as burning, garbage grinding, and salvage, or by the municipality employing incineration or composting. The calorific value of refuse is continually increasing but the nutrient content, of importance in decomposition by composting, is continually decreasing. This paper is concerned with the composting process and the present and future status of composting in the U.S.

Combined treatment of refuse and raw sewage sludge by composting will improve the economy of the process, enhance the decomposition, and augment both structure and nutrient content of the compost.[2, 3, 4] There are several examples of refuse-sludge composting in Europe[5] and three plants have used refuse and sludge in this country (Williamston, Michigan; Largo, Florida; and experimentally at Altoona, Pennsylvania). The added expense of incorporating sludge with refuse is small compared to the cost of sludge treatment in a conventional wastewater treatment plant. Since moisture must usually be added to mixed refuse for optimum composting, sludge can be added to provide moisture along with other benefits. However, combining all of the sludge with the refuse from the same contributory population will introduce excessive moisture unless sludge thickening is practiced. There are several relatively inexpensive means of concentrating or dewatering sewage sludge.

Most plants built in recent years have relied on the sale of compost and salvaged materials for their primary income, coupled with a nominal payment by the municipality for disposal. Inability to dispose of large quantities of compost at a favorable price greatly affects the economy of the process and is probably a major factor in the closing of six U.S. composting plants during 1962 – 1964. Although compost contains some plant nutrients and trace elements, its principal value is in its use as humus for soil building or conditioning. It can be fortified with

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additional chemical nutrients to form an organic-base fertilizer. Although there is no widespread demand for compost in commercial agriculture now and no startling increase in demand is anticipated, new uses and markets may be developed. However, the larger the compost plant the greater the difficulty to be expected in selling or disposing of the entire compost output in a given marketing area.

A second problem in composting relates to the hygienic aspects in plant operation and in compost utilization. Cleanliness and prompt handling of the wastes are essential to avoid the production of odors and propagation of such vermin as flies and rats. Plant operators must be aware of potential hazards to health and safety inherent in processing refuse and sewage sludge. It must be demonstrated by suitable microbiological tests that pathogenic organisms which might occur in the raw wastes are destroyed by the various methods used for composting and curing. This is particularly important when raw sewage sludge is used in the process.

In normal composting, the aerobic thermophilic decomposition produces temperatures of 140 degrees Fahrenheit or higher for several hours or even days. Such a time-temperature exposure is believed to be adequate to destroy most, if not all, pathogens. European and South African studies have consistently indicated the safety of compost produced by a number of processes.[6] [7] [8] Several reports have indicated that anti-microbial substances are produced during composting and that their action may be as important as time-temperature in destroying pathogens. However, few studies of this type have been made in the United States.

TABLE I. Municipal solid waste composting plants in the United States

Location	Company	Process	Capacity ton/day	Began operation	1965 status
Altoona, Pennsylvania	Altoona FAM Inc., Fairfield Engg Co	Fairfield-Hardy	45	1951 1963	Operating
Largo, Florida	Peninsular Organics, Inc., National Composters Co	Peninsular Organics	50	1963[1]	Operating
Norman, Oklahoma	International Disposal Corp	Naturizer	35	1959	Closed 1964
Phoenix, Arizona	Arizona Biochemical Co	Dano	300[2]	1963	Closed 1963[3]
Sacramento Co., Calif.	Dano of America, Inc.	Dano	40	1956	Closed 1963
San Fernando, Calif.	International Disposal Corp	Naturizer	70	1963[4]	Closed 1964
Springfield, Mass.	Springfield Organic Fertilizer Co.	Frazer-Ewerson	20	1954[5]	Closed 1962
Williamston, Mich.	City of Williamston	Riker	4	1955	Closed 1962
Wilmington, Ohio	Good Riddance, Inc.	Windrow	20	1963	Operating

[1] Date of initial operation of the original Hardy plant is unknown; plant rebuilt in 1963.
[2] According to European Dano practice, the plant capacity is about 175 T/day.
[3] Reported to be back in limited operation, March 1965.
[4] Date of initial operation is unknown; continuous operation began in July 1963.
[5] Partially burned in 1958; rebuilt in 1961.

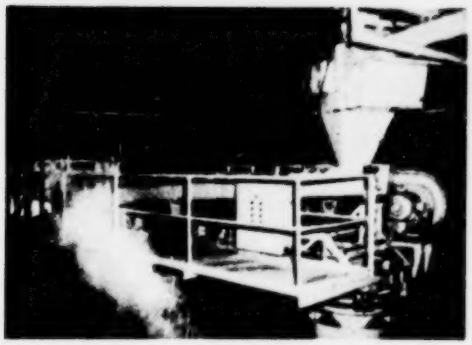

FIGURE 1. The Fairfield-Hardy composter at Altoona, Pennsylvania

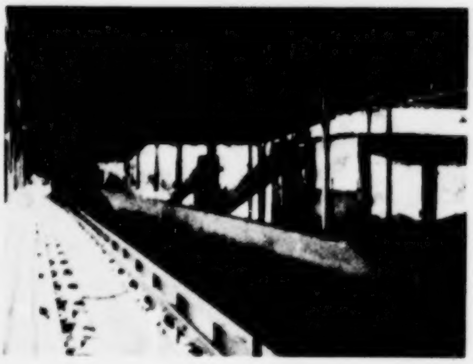

FIGURE 2. The open-trough digester at Largo, Florida

Composting Plants in the United States

Table 1 shows the plant built in recent years and gives their status as of early 1965. Brief comments are given on each of the plants.

Altoona, Pennsylvania[9]

For a number of years the Altoona FAM, Inc., plant composted garbage with combustible rubbish by the windrow method. In December 1963 the Fairfield Engineering Company began operation of a Fairfield-Hardy composter at the Altoona plant. This was the second installation of a Hardy digester (see Largo, Florida).

The refuse is ground in a wet pulper followed by two dewatering presses. The ground material is composted for a period of about 5 days with intermittent stirring and aeration in the Fairfield-Hardy digester. Stirring is provided by augers suspended from a rotating bridge in the circular tank. Air is provided by means of a blower and air pipes embedded in the floor of the tank. Normal operating temperatures are about 140—160 degrees Fahrenheit. The plant has a capacity of about 45 T/day but normally operates at about 18—23 T/day. Successful experiments have been run in which digested sewage sludge was added to the ground refuse. The compost is reported to sell readily as a soil conditioner or as an organic base for fertilizer. However, the company buying compost from the Altoona plant ships most of it in bulk a distance of more than 500 miles.

Largo, Florida

The original Largo plant was built by Peninsular Organics, Inc., and operated for a few years using a Hardy composter. In 1963, National Composters Company refinanced Peninsular Organics Company and rebuilt the Largo plant using a digester of their own design. The plant has a capacity of 50 T/day. Operating 5 days a week it treats 40—50 T/day of mixed refuse to which is added 1,000—1,500 gpd of essentially raw sewage sludge.

The steps involve sorting and magnetic separation, double hammer-milling, mixing of ground refuse and sludge, composting for 6 days in a long narrow open tank with turning and aeration, regrinding, screening, and bagging. The digester is 12 feet wide by 6 feet deep by 280 feet long having a metal false bottom with air holes. The turner is a rail-mounted bucket elevator moving in either direction the length of the digester. Material is turned twice during composting. The final compost has a ready market in bulk or when fortified to a 3 : 2 : 2 analysis and bagged. A test for pathogens by the Florida State Board of Health Laboratory gave results which were "quite favorable."[10]

Norman, Oklahoma[11]

The first plant using the Naturizer process was built a number of years ago by the Naturizer Company of Norman, Oklahoma. This plant and the later one at San Fernando, California, were taken over subsequently by SACS, Inc. (Salvage and Conversion Systems), which entered into a marketing agreement with Westinghouse Electric Corporation. In February 1965, these companies, together with Allstate Insurance Company, formed a new company, International Disposal Corporation, which incorporated the assets of SACS. The plant treated the 35 T/day of mixed refuse from the city of Norman. Operations were discontinued in 1964 except for experimental purposes.

Two unique features of the plant were a specially-designed swing hammermill and the Naturizer composter. The digester system provided 6-day retention in two, three-story buildings with a movable floor in each story. Compost was sold either in bags or bulk. Considerable time and effort were expended to build up a market for the product, with sales activity extending as far away as Dallas.

Phoenix, Arizona[12]

The Phoenix composting plant was the second Dano-type plant in the U.S. and was built by Arizona Biochemical Company to process 300 T/day of refuse. Originally two Dano biostabilizers were provided but two additional units were added in March 1963. Even then, by European practice of 3-day digestion in the biostabilizers, the capacity of these rotating drum units is only about 175 T/day. The

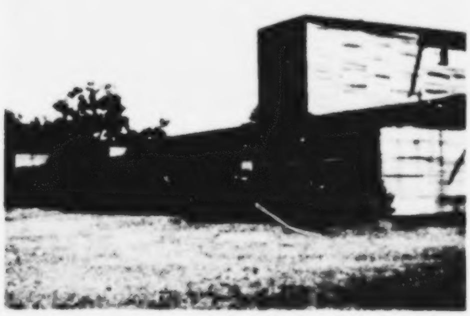

FIGURE 3. Exterior of the Norman, Oklahoma, composting plant

FIGURE 4. Aerial view of the composting plant at Phoenix, Arizona

plant provides sorting, magnetic separation, salvage, hammermill grinding, composting in the biostabilizers for 24 to 30 hours, screening, regrinding, and deglassing, and further composting in windrows. When an adequate market for compost had not been developed by late 1963, the plant was shut down. It was reported to be back in limited operation in March 1965.

Sacramento County, California[13]

The plant in Sacramento County, built by Dano of America, Inc., in 1957, was the first Dano-type plant in the U.S. It had a capacity of about 40 T/day of refuse and, except that only one biostabilizer unit was employed, operated in much the same way as the Phoenix plant. The plant was closed in 1963.

San Fernando, California[14, 15]

The San Fernando compost plant was built by Lockheed Aircraft Corporation and operated by General Conversions System Corporation. Later, the plant was taken over by SACS, Inc., and finally by International Disposal Corporation, Shawnee, Oklahoma. The plant had a capacity of 70 T/day of refuse but operated at only about 40 T/day. It was an improved version of the process developed at the Norman, Oklahoma, plant. Appreciable salvage operations were performed. It was necessary to provide an afterburner on top of the composting unit to comply with Los Angeles County Air Pollution Control District requirements to ensure that no odors would be discharged.

The plant was shut down in October 1964. Compost was sold in bags and in bulk. A unique development for the use of compost was called "Sta-Soil" which was a water suspension of compost, chemical fertilizer, grass seed, and shrub seed. It was sprayed over denuded slopes, or cuts and fills, to provide a blanket against soil erosion and a "soil" in which grass and shrubs would quickly take root.

Springfield, Massachusetts[16]

The Springfield plant was built in 1954, partially burned down in 1958, and was rebuilt in 1961. It was a Frazer-Eweson process plant owned by the Springfield

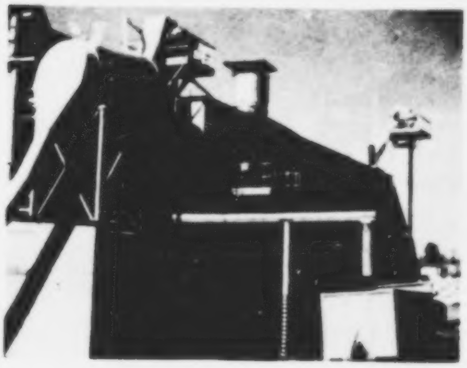

FIGURE 5. San Fernando, California. **Afterburner is at top center**

FIGURE 6. Exterior of the compost plant at Springfield, Massachusetts

Organic Fertilizer Company. The plant had a capacity of 20 T/day of garbage from the city of Springfield. The garbage, being too wet to compost aerobically, was held for about two days to dewater. This frequently created fly, rat, and odor problems. The city failed to renew the contract in 1962 and the plant was closed.

Williamston, Michigan[17]

The Riker System plant at Williamston was built in 1955 and operation was taken over by the city in 1956. The 4 T/day plant treated garbage, vacuum-filtered raw sewage sludge, and corn cobs. Ground garbage and corn cobs, mixed with the sludge cake, were composted for 21 days in two 4-compartment vertical composters. The plant was closed in 1962 primarily because a nursery in Detroit stopped purchasing the compost.

Wilmington, Ohio

The 20 T/day refuse composting plant at Wilmington was built about 18 months ago by Good Riddance, Inc. A minimum of sorting is provided and two hammermill grinders are used in series. The ground refuse is composted in windrows where it is turned weekly by means of a front-end loader for an indefinite period of time. Difficulties have been experienced in selling the finished compost.

There is another windrow composting plant at Oahu Prison, Honolulu, which handles all of the solid wastes of the prison in addition to some food processing wastes.[18] There was also a very small Earp-Thomas type plant near Reading, Pennsylvania, built by Keystone Organic Corporation, which was found to be shut down in October 1961. The plant was reported to have been moved to Brooklyn, New York, but information is lacking as to its operation.

Proposed Compost Plant Installations

Present indications are that Houston, Texas, may soon have the most and the largest compost plants of any U.S. city. Three companies (National Organic Corporation, Biochemical Sales, Inc., and Metropolitan Waste-Conversion Corpora-

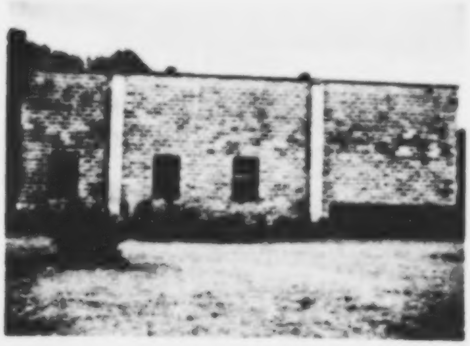

FIGURE 7. Building of the composting plant, Williamston, Michigan

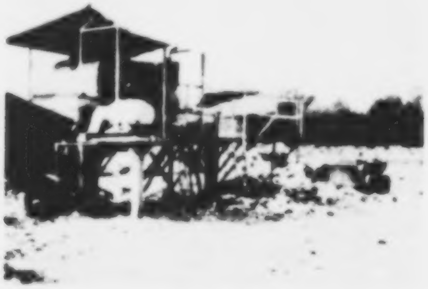

FIGURE 8. Refuse reception and primary grinder at Wilmington, Ohio

tion) have submitted contracts for plant construction at their own expense with each company to receive \$2.75 – \$3.50/T from the city for treating the refuse. One plant was reported to be of 350 T/day capacity and the others are expected to be in the 300 T/day range. At last report the city had only signed one of the contracts.

A point of grave concern, however, is how the enormous amount of compost produced by the three proposed plants in one area (possibly 400 T/day at 25 per cent moisture) can be marketed profitably. About 18 months ago it was reported that the production of Hou-Actinite (heat-dried activated sludge sold by the city) was greater than the market. The amount of Hou-Actinite sold during the period 1937 – 1944 varied from 846 to 2,136 T/yr whereas the compost on a dry weight basis would be expected to be 40 to 100 times this amount if the raw refuse amounts to 950 T/day.

A compost plant to treat refuse and sewage sludge (about 300 T/day) is under construction at Mobile, Alabama. All of the refuse of Mobile, estimated at 225 T/day at present, will be processed but only a portion of the sludge (digested sludge from a plant serving about half of the city). In this case the city is to build and operate the plant, selling all of the compost to a private concern at a guaranteed price plus a share of the profits. Again, difficulty in marketing the large amount of the compost may be experienced in Mobile.

A contract has been signed by the city of St. Petersburg, Florida, for a composting plant to treat 105 T/day of refuse. The Naturizer system plant would be privately built and operated with payment by the city amounting to \$3.24/T. This plant will be competing with the nearby Largo plant for the compost market.

NORCO (National Organic Corporation, Atlanta) reports that four U.S. plants are planned with construction of one (Elmira) to be started in May 1965. These plants are reported to be in Elmira, New York; Irondequoit, New York; Houston, Texas; and New Orleans, Louisiana. The system is the same as formerly used at McKeesport, Pennsylvania, and now used at Kingston, Jamaica. It includes double grinding and windrow composting, much the same as at Wilmington, Ohio. (A recent article[19] reported that the amount of refuse from Kingston and St. Andrew, Jamaica, being processed has been reduced from about one-half to one-tenth due to lack of compost demand.)

The Proposed TVA-PHS Research and Demonstration Plant

It appears that in spite of the number of recent plant failures in the U.S. – primarily of pilot scale operations – there is increasing activity in the composting field. Several other cities are considering compost plants. However, it is clear that research and development is urgently needed to determine the specific value of compost for various uses and to develop and test new uses for compost.

The Tennessee Valley Authority and the Public Health Service have long recognized the problems of water, land and air pollution, public health, safety, and nuisance resulting from unsanitary refuse handling practices. Extensive laboratory and pilot plant studies on composting of municipal refuse and sewage sludge have been made by the Public Health Service.[2 3 20] Theoretically, the composting processes appeared to present a satisfactory method of waste disposal. Practically, it was decided that more research was needed in certain aspects of the composting process and one or more methods needed to be demonstrated in full-scale plants to test and develop equipment and operational methods in order to obtain reliable unit cost data.

With our similar interests and varied capabilities, TVA and PHS after preliminary studies, united in proposing a "Solid Wastes Composting Research and

Demonstration Project" in which a full-scale composting plant would be constructed and operated at a city located in the Tennessee Valley area and the various research and development studies needed could be undertaken. Following the joint approval of a letter of agreement, the senior author was transferred to the Headquarters, TVA, Health and Safety Division in Chattanooga so that detailed work on this project would be facilitated. Contingent upon the appropriation of funds, a demonstration composting plant will be designed and built within the next year. Upon completion of equipment installation during the following year, the plant will be ready to process all of the organic wastes from a municipal collection system and all the sludge from the city sewage treatment plant.

In addition to testing and modifying equipment and operations and to maintaining accurate operational and cost records, two major studies will be undertaken. The TVA Agricultural Development Division has already started experimenting with the use of compost obtained from existing plants as a soil amendment. These studies will be extended to include various uses of the basic material and of compost fortified with chemical fertilizers. Enlargment of the market potential will be studied to include orchard and forest culture, reclamation of strip mine areas, seeding and erosion control of construction scars along our highways and expressways, and similar uses.

The Public Health Service will conduct studies to determine the hygienic safety of the composting process and of the material produced. These studies will include information on the survival of pathogenic organisms and indicator microorganisms throughout the various phases of the composting process.

The project is being designed to demonstrate a sanitary and economical process for treatment of organic wastes, while reducing or eliminating some troublesome public health problems, and to promote the conservation of waste organic material for use in soil improvement, erosion control, and land reclamation.

As you may already know, a "Solid Waste Disposal Act" embodying many of these objectives has been introduced by nine representatives in the present session of the House. The bill proposes authorization for: (1) a national research program on improved methods of solid waste handling, processing, and disposal; (2) technical assistance to state and local governments in developing solid waste disposal programs; (3) matching funds for demonstration projects; and (4) training. If approved, the act would provide a total of $43.5 million over a 4-year period to be administered by the Public Health Service. It is gratifying to note the increased congressional interest in a nationwide solid waste control program.

Bibliography

1. Solid Waste Handling in Metropolitan Areas. – Division of Environmental Engineering and Food Protection, Public Health Service, Department of Health, Education, and Welfare, p. 41. September 1963.
2. Wiley, J. S. and J. T. Spillane. Refuse-Sludge Composting in Windrows and Bins. – ASCE Proc., Paper 2941, SED 87 (SA5), pp. 33 – 52. September 1961.
3. Wiley, J. S. Refuse and Refuse-Sludge Composting. – Jour. Boston Soc. of Civil Engineers, 49 (1), pp. 13 – 25. January 1962.
4. Black, R. J. Combined Disposal of Sewage Sludge and Refuse. – Proc. 3rd Pittsburgh Sanitary Engineering Conference, Municipal Solid Wastes Disposal, pp. 71 – 76. November 4, 1961; Reprinted in: Amer. City, 77 (8), p. 139. August 1962 and Compost Science, 2 (4), pp. 16 – 17. Winter 1962.

5. Braun, R. The Processing of Refuse and Sludge.— Compost Science, 2 (2), pp. 27 — 29. Summer 1961.
6. Knoll, K. H. Compost Preparation from the Hygienic Viewpoint.— Intern. Congr. on Disposal and Utilization of Town Refuse, Scheveningen, the Netherlands, mimeo, 12 pp. April 27 — May 1, 1959. Also: Public Health and Refuse Disposal.— Compost Science, 2 (1), pp. 35 — 40. Spring 1961.
7. Wiley, J. S. Pathogen Survival in Composting Municipal Wastes.— Jour. WPCF, 34 (1), pp. 80 — 90. January 1962.
8. Krige, P. R. The Utilization of Municipal Wastes.— Rept. No. 211, Council for Scientific and Industrial Research, Pretoria, South Africa, 71 pp. 1964.
9. Schulze, K. L. The Fairfield-Hardy Composting Pilot Plant at Altoona, Pa.— Compost Science, 5 (3), pp. 5 — 10. Autumn-Winter 1965.
10. Vanderveld, J. Jr. Design and Operation of Sanitary Landfills. — APWA Yearbook, pp. 242 — 246. 1964.
11. McGaughey, P. H. Refuse Composting Plant at Norman, Oklahoma.— Compost Science, 1 (3), pp. 5 — 8. Autumn 1960.
12. Valianos, J. N. Full-Time Schedule for Phoenix Compost Plant.— Compost Science, 3 (4), pp. 9 — 10. Winter 1963.
13. Golueke, C. G. Composting Refuse at Sacramento, California.— Compost Science, 1 (3), pp. 12 — 15. Autumn 1960.
14. Golueke, C. G. San Fernando Plant Uses "Total System Concept."— Compost Science, 3 (3), pp. 5 — 8. Autumn 1962.
15. Anonymous. Composting Gets Tryout.— Amer. City, 80 (4), pp. 99 — 102. April 1965.
16. Anonymous. Springfield, Massachusetts.— Compost Science, 2 (1), p. 17. Spring 1961.
17. Steffes, M. J. Williamston, Mich. Conducts Successful Composting Operation.— Amer. City, 73 (8), pp. 94 — 95. August 1958.
18. Eriksson, A. Waste Treatment at Hawaii's Oahu Prison.— Compost Science, 1 (4), pp. 44 — 45. Winter 1961.
19. Anonymous. Word of Caution from Kingston, Jamaica.— Public Cleansing, 55 (2), p. 103. February 1965.
20. Wiley, J. S. and G. W. Pearce. A Preliminary Study of High-Rate Composting.— ASCE Proc., Paper 846, 81, pp. 1 — 28. December 1955.

*THE WASTE INCINERATION PLANT OF THE "CONSORZIO PER L'ELIMINAZIONE DEI RIFUITI DELLA ZONA LUGANESE"**

By Ing. Paolo Regazzoni, President of the "Consorzio"

The city of Lugano and the numerous communities surrounding it found themselves forced to solve the weighty problem of the city's solid waste disposal. Because solid waste occurs in considerable quantities, especially in summer, it became a real nuisance from the hygienic and aesthetic points of view, and was detrimental to tourism, one of the chief sources of revenue to the local economy.

The collected refuse was being deposited in various dumps, which had a very bad effect because of the insects and rodents it attracted, and the bad smell from fumes produced by spontaneous combustion of the refuse. Further incalculable harm to tourism was caused by the dumping of domestic refuse in rivers and brooks as well as in the lake.

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* Consortium for Waste Disposal in Lugano and Environs (Note by the Italian-German translator: henceforth designated as "Consorzio.")

Induced by the county hygiene laboratory of Lugano, the most important municipalities concerned founded a consortium to investigate methods for more efficient disposal of solid refuse.

Created by a county order of 4 November, 1959, the "Consorzio" now comprises 50 communities of the Lugano District with about 63,500 inhabitants.

Although not members of the Consorzio, another 30 communities use the Consorzio's incineration service so that the entire population taking advantage of the service amounts to some 90,000 persons.

As the holiday season brings about 10,000 tourists to the area, and Sunday visitors are several thousand more, these numbers have to be taken into account also.

The amount of refuse per inhabitant varies considerably in that about 65% of the communities in the Consorzio live on industry and tourism, and refuse is collected daily; of the other 35% of the communities, predominantly agricultural, refuse is collected only two or three times a week.

The first problem which the Consorzio had to meet was choosing the method of refuse disposal to be used, i.e., incineration or composting. The Consorzio nominated a technical committee to examine this problem.[*]

From a number of analyses carried out in the course of a few days in March 1961 – this time seemed particularly favorable for the investigation because it could be assumed that the amount of refuse collected then corresponded to the amount of refuse from the local population – it was found that the refuse contained a large proportion of combustible substances, with a lesser content of organic, biologically decomposable substances.

It must be pointed out that during the holiday season combustible refuse and the number of variegated wrappings increase considerably, whereas the amount of organic, biologically decomposable substances decreases. This tendency has become more marked as households favor more and more such foodstuffs and daily consumer goods as are sold in ready packings.

On the basis of the foregoing factors and the results of the analyses of the calorific value of the refuse, tabulated in Table 1, the technical committee suggested to the Consorzio that incineration should be the method of waste disposal for the city.

After the Consorzio had decided on incineration, the technical committee studied offers received and visited numerous plants. It selected Vénien-SAFII furnaces, proposed by S.p.A. FORNI ED IMPIANTI INDUSTRIALI ING. DE BARTOLOMEIS, Milan (Italy).

Having accepted the recommendation of the technical committee, the Consorzio ordered an incineration plant consisting of two furnaces, each of which had capacity of 50 tons per day. They were put into operation in February 1964.

The corresponding budget for 1960/61 amounted to Fr. 2,200,000. – including Fr. 280,000. for acquiring the land (18,000 m^2).

An accurate and definitive calculation of the costs is not yet possible. It is certain, however, that expenditure will exceed the budget owing to rising prices

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[*] The governing body of the Consorzio, charged by the consultative groups with building the disposal plant, is composed as follows:
President: Ing. Paolo Regazzoni; Vice-president: former county engineer Ing. Bernardo de Bernardis; Ing. Mario Bauer, city engineer of Lugano; Ing. Giacomo Grignoli, Mayor of Massagno; Ing. Armando Brazzola, town engineer of Paradiso.

TABLE 1. Refuse composition and its lowest usable calorific value (UCV)

Date	Area	Composition in percentage			Lowest UCV
		Moisture content	Combustible substances	Noncombustible substances	
1.3.61	Massagno-Carabia-Pazzallo	28.-	41.-	31.-	1,111
2.3.61	Gandria-Scairolo-Barbengo Figino-Carabietta-Agnuzzo	30.5	34.5	35.-	1,411
3.3.61	Massagno	33.-	44.2	22.8	1,765
6.3.61	Lugano center	35.8	42.1	22.1	1,631
7.3.61	Lugano outskirts	26.-	48.6	25.4	1,879
	Mean value	32.7	42.-	27.3	1,560

(materials, higher wages, special building measures for protection of the landscape, supplementary work that proved necessary during building operations, preparation of the forecourt and approach road). The new plant has fulfilled its purpose.

The aforementioned sum was raised through a loan from a public corporation plus a government grant of 25% of the needed money.

The communities of the Consorzio will share in the operating costs, payment of interest, and redemption of the debt by payment calculated according to the weight of each community's incinerated waste.

The incineration plant was built in Boggio because this is the only community situated in flat country, in the geographical center of gravity of the communities making up the Consorzio, and also in the center of a developing industrial area, which will utilize in the near future the heat produced through incineration of waste.

The Consorzio observed the building operations carefully and was especially concerned with the economy and esthetics of the plant. Thus, for instance, large service rooms, sanitary installations for the staff, and a meeting and reception hall were built under the ramp leading to the bunker and the main building opposite.

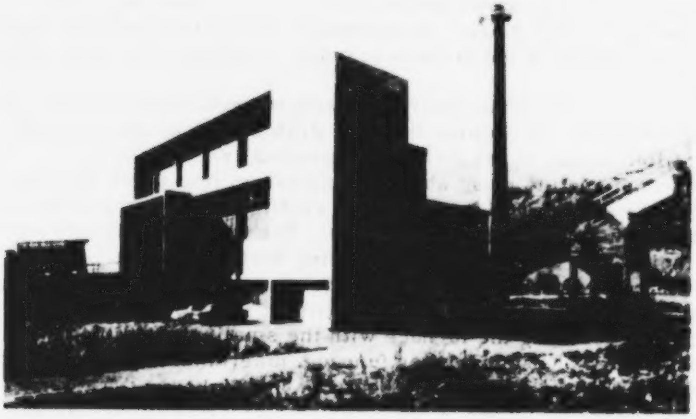


FIGURE 1. Intake side of the plant

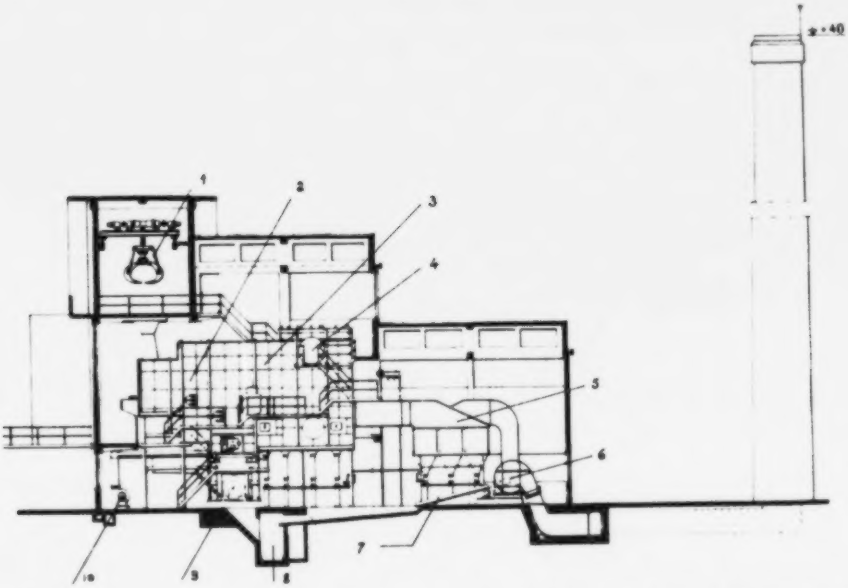


FIGURE 2. Main section: 1 – grab, 2 – furnace, 3 – stilling chamber, 4 – space for boiler, 5 – flue-gas dust retainer, 6 – induced draft fan, 7 – dust exhaust, 8 – clinker pit, 9 – grate, 10 – undergrate blower

Figures 1 and 2 illustrate the complete plant.

The refuse carts are driven onto an automatic scale where the weight of the delivered refuse is ascertained; this is the basis for fixing the charge each community has to pay. The refuse carts then move in reverse up the ramp to the bunker room where they are emptied through two large hinged gates that open inward.

A light signal indicates the gate to be used. It is opened automatically by a selenium cell or a special push button actuating a special hydraulic device which permits steady and smooth opening of the gate.

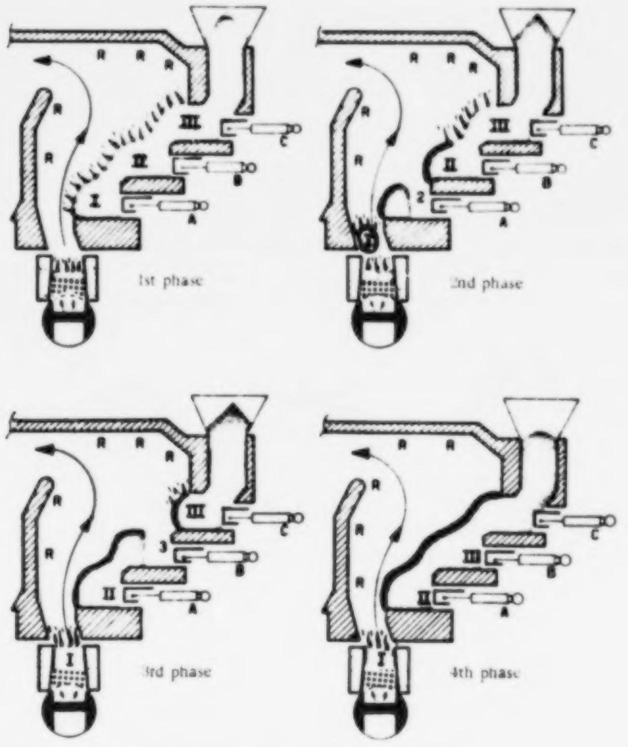
In the bunker room a traveling crane with grab is controled by a crane operator. A large, dustproof window enables the worker to observe how the refuse is scooped up from the bunker room. An automatic signal notifies him when the refuse in the filler funnel of the furnace is below a certain level and, consequently, a new load is required.

The crane operator scoops up the refuse with the grab bucket from a suitable spot in the bunker room. Following this, the grab bucket is lifted and the crane travels to the filter funnel of the furnace automatically.

The bunker room and the room above the furnaces, into which the traveling crane conveys the refuse, are illuminated by spotlights and are pressurized to prevent escape of dust and unpleasant smells. The walls are smooth and without protrusions, facilitating cleaning and preventing dust settlement.

To incinerate refuse which sometimes is very wet, and to attain the high temperatures that ensure complete combustion without added fuel, the refuse has to be dried first, thus reaching the furnace with the smallest possible moisture content. The Vénien-SAFII incinerator furnace, diagrammatically illustrated in Figure 3, satisfies these requirements best.

The feed and predrying slides of the patented SAFII system are actuated one after the other, starting with slide A, which pushes forward an amount of the refuse heap corresponding in length to the specific distance of the push, and drops it into the



1st phase

2nd phase

3rd phase

4th phase

FIGURE 3. Functional diagram of the Vénien-Safit furnace

incinerator furnace. Thus, the sum total of the new surface of the refuse is colder than the old surface, which was incandescent. This cold surface can absorb a maximum of radiated heat from the incandescent furnace wall, which the old surface could no longer do because it was in thermal equilibrium with R, the heat sources. On being retracted, the slide forms an empty space into which can drop a further part of the substance to be burned, and which is in front of slide B. This substance, in turn, is covered by other colder material dropping down as slide B is activated. Similar action occurs at slide C, which conveys new refuse from the feed funnel, and subsequently through the foregoing phases.

Thus, at the end of each feed cycle, the surface exposed to radiation is completely renewed and cooled; this ensures the most favorable conditions for the surface to receive the largest possible amount of heat from the heat sources.

In addition to the foregoing factors, the continuous movement of refuse ensures that all the waste is continuously mixed, while the space under the slide has a constant, small flow of air to keep the area clean.

The slides are so built that unburned material cannot pass through the device.

The combustion chamber is square with rounded corners, its walls forming a sort of lined boiler, equipped with tubes which produce steam for the sanitary installations and for heating the rooms connected to the plant. This boiler is built so that it can be connected to the main waste-heat boiler — with a capacity of 2,500 kg/hr steam per furnace — as soon as the Consorzio decides to install the boiler in a room prepared for it.

The predried waste burns in a thick layer in the combustion chamber. The air required for combustion enters through the grate lying partly under the layer of refuse and partly above the chamber.

At the lower end of the combustion chamber there is a Vénien grate, of a type which has been used for more than 30 years in the furnaces of Toulouse (France) and has been found to be really successful. The grate is a hollow cast-iron cylinder revolving around a horizontal shaft, actuated by an electromechanical drive which functions intermittently, according to a previously established program.

Figure 4 shows the grate in various phases of its work. The hollow cylinder is divided by a partition into two opposing chambers: one is a blower chamber with walls of slightly bent, easily replaced plates containing many small holes through which air can enter; the second chamber serves for clinker removal.

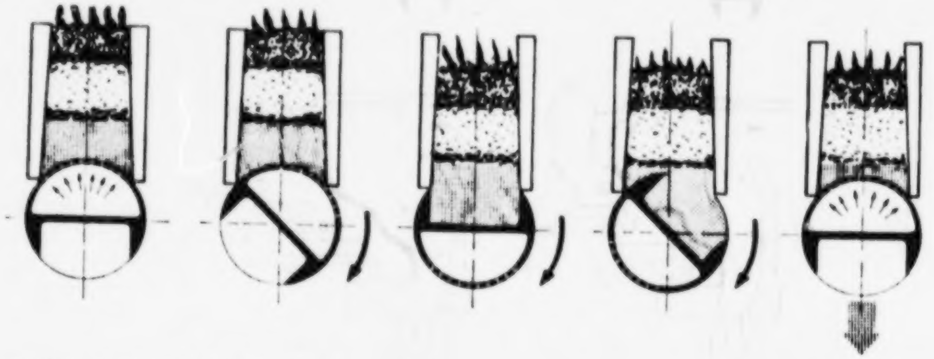


FIGURE 4. Functioning of the Vénien grate

During the combustion phase, the perforated wall is directed upward and is in contact with the charge of the combustion chamber.

As soon as the layer of slag is sufficiently thick, the cylinder turns upward through 180° so that the chamber can be filled with clinker. The cylinder then continues rotating and the clinker is emptied.

An energy-limiting device automatically changes the direction of the grate's rotation until all objects that could prevent its rotation are removed. This is facilitated by the chamber's longitudinal shape and its dimensions which permit the removal of fairly large bodies.

Boiler and grate are mounted on a chassis with wheels, and can be withdrawn from the furnace for maintenance purposes of which only a minimum is required.

The clinker coming from the combustion chamber drops into a collecting trench filled with water, from where it is lifted by a grab bucket and conveyed through an inclined channel into a bunker, whence it is eventually loaded for final transport.

Each furnace is provided with a large dust separator in which the main waste-heat boiler can be installed at a later date.

In this plant the fumes are cooled by water jets or admixture of cold air. Subsequently a multi-cyclone fly-ash separator removes the remaining dust from the fumes from each furnace. Centrifugal ventilators, providing the necessary air aspiration, convey the fumes into a stack 40 m high. Owing to the high temperature of the fumes, a white vapor cloud forms at a certain height, which permits the minutest fly-ash particles to spread sufficiently to prevent pollution of the environment. The high combustion temperature ensures absolutely odorless fumes.

The incineration plant functions completely automatically; human labor is confined to supervision and control because the waste does not require any special treatment during combustion, and manual labor is unnecessary in connection with incineration.

All the required instruments are mounted on the control panel which provides remote control of the various other control and charging devices.

The furnaces can function independently or together, if necessary; they may operate, also, for two eight-hour shifts a day and be out of operation for the remaining eight hours. Operation can be renewed without adding fuel.

The first furnace was fired on 12 February, 1964, at a time when the buildings, as well as the second furnace, were still under construction and, in addition, all the approaches, roads, drains, etc. had still to be completed. The furnace lining was predried and heated by burning wood in the combustion chamber, and only the day before operation was to begin was the combustion oil burner, intended for regular use, lit. This phase lasted about a week, during which time about 80 tons of wood and 300 kg of oil were burned.

The refuse, which could be ignited very easily, was charged into the furnace when the combustion chamber lining had been heated to a temperature of approximately 450°C. After 5 hours, the combustion chamber temperature was more than 900°C, and the furnace could be used normally. This furnace was in continuous operation until 30 May, going out of operation only because the second furnace which had been fired on 12 May was found to be more than sufficient to incinerate the entire refuse collected in the area of the Consorzio.

The second furnace, which had been fired through the same procedure as the first one, is still in operation. In early August, the first furnace was fired again to cope with increased refuse collection, which always occurs in the summer, and also to deal with the maximum daily output, which often exceeds 80 tons.

The diagram in Figure 5 shows clearly the increase in average refuse occurrence in the summer months.

The diagram in Figure 6, on the other hand, shows the amount of refuse conveyed to the plant within a week, for which four characteristic weeks were selected from different months.

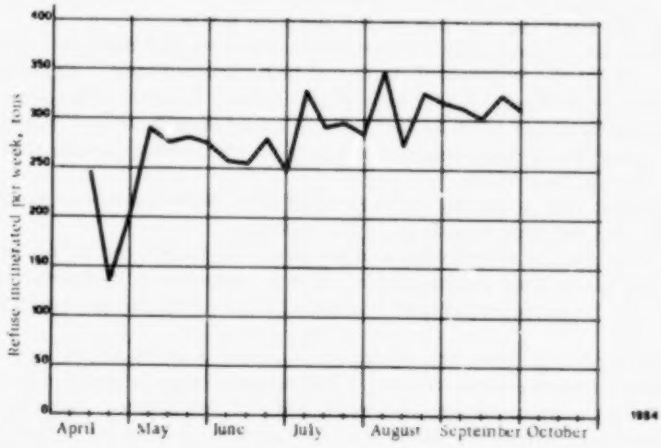


FIGURE 5. Weekly intake in Lugano, 1964

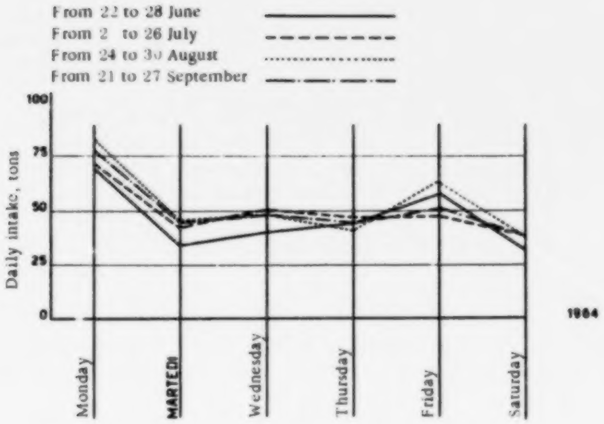


FIGURE 6. Daily intake in Lugano, 1964

After the plant went into operation, it was found that staff performance had to be increased. It was particularly important to avoid those interruptions which first arose from the staff's need to adapt to new kinds of work performance. After the initial period, the plant worked smoothly, incinerating both domestic refuse and waste from large plants and private enterprises.

Various packing materials, bottles, glass and cans, sometimes in considerable quantity, arrived at the plant without causing trouble in operation.

During all the time the plant has been in operation no fuel oil has been needed, although the refuse charged into the furnace has a very low calorific value. Its incineration is sufficient to achieve a temperature of more than 800°C in the combustion chamber. Thus complete incineration of refuse can be ensured without the least trace of an unpleasant smell escaping. The mean temperature in the combustion chamber can be maintained at 950–1050°C. It would even have been possible to attain temperatures of more than 1100°C, but this is purposely avoided to prevent molten ash forming a crust on the furnace walls.

The slag is granular, completely burned, free of smell and sterile. Its volume amounts to about 10% of the volume of material to be incinerated. Experiments show that its weight is between 28 and 32% of the refuse weight. The specific weight of wet clinker is about 1100 kg/m^3, which corresponds to a dry weight of 830 kg/m^3. This specific weight depends largely on the cans of which there is a very high proportion in the refuse.

The slag is dumped into a nearby former sand pit. Some of it was used as filler material for the surrounding area of the plant.

Refuse containing iron is sterilized, and scoured, and any zinc or tin plating is removed. The residue is then pressed, its volume reduced by incineration in the furnace, after which it can be separated from the clinker with simple apparatus, and sent to foundries.

The fumes, which emerge from the 40-m stack, form a white vapor cloud which almost immediately disperses into the air. No fall-out of solid particles such as soot, ash, or such has ever occurred in the vicinity of the plant. Also no bad smell has ever been noticed in the plant and its vicinity, and in its immediate vicinity a modern metal-structure plant has been built, with others to follow in the near future.

In the short period between consideration of the project and completion of the plant, the quantity as well as the quality of the refuse changed considerably.

Especially the weight increased, but the volume of waste increased even more, because the mean specific weight of the refuse decreased. The percentage of combustible components also increased; consequently, the calorific value of the refuse also increased. At present, the refuse consists largely of wrappings of products sold in large quantities, plastics and cans. On the other hand, decomposable organic components are noticeably decreasing.

From this review, conclusion may be made that the facts fully justified the Consorzio's forecasts and confirmed as correct the choice of an incineration plant for waste disposal.

This report confirms that the choice of incinerator for waste disposal is correct. It proved fully satisfactory for the hygienic and esthetic protection of the environs. It is possible, therefore, to include waste incineration plants among the few industrial enterprises which may be built in the immediate vicinity of large residential areas.

*INHIBITION OF ANAEROBIC ZONES IN COMPOST WINDROWS BY STAGEWISE PILING**

By Dr. Lothar Böhme, Institut für Kommunalwirtschaft Dresden (Director: L. E. Uhlrich)

The stagewise piling method (SPM) for windrow composting was developed by the author in 1957 and 1958, and tested in numerous experiments in composting undigested sewage sludge[3].

The use of SPM can prevent the formation of anaerobic zones with all their disadvantages.

Anaerobic zones are formed when inadequate oxygen supply leads to microbiological conversions. The dark to blue-black zones have most undesirable effects on both the composting process and plant growth.

Disadvantages of Anaerobic Zones

In zones with poor ventilation, composting either does not occur at all, occurs in the wrong direction, or is considerably inhibited.

In such zones a lower-degree warming is observed largely (Table 1).

Thus, because of the lower temperature the hygienic effect is a priori less. Moreover, it is probable that the antibiotic effects are less because most of the antibiotic-forming microorganisms require aerobic conditions.

Ammonia is formed in higher amounts in such zones, thus increasing the risks of nitrogen losses.

On the other hand, a higher NH_3 (or ammonium nitrogen) level may have a favorable N-effect on plant growth when immediately applied to soil because it prevents volatilization of ammonia.

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* This contribution is a revised excerpt, supplemented by new research, of the Inaugural Dissertation "Problems of Composting Undigested Sewage Sludge" given at the Agricultural-Horticultural Faculty of the Humboldt University Berlin, 1961.

TABLE 1. Temperature of windrow with and without anaerobic zone

Depth of windrow	Windrow without anaerobic zone		Windrow with anaerobic zone	
cm	zone	temperature °C	zone	temperature °C
5	Aerobic	54	Aerobic	55
10	zone	56	zone	56
15		57		57
20		59		59
25		60		60
30		61		60
35		62		60
40		63		58
45		62	↓	55
50		62	Anaerobic	51
55		61	zone	46
60		61		44
65		61		42
70		60		43
75		60		44
80		57		42
85		55		41
90		54		42
95		52		40
100		44		36
Bottom of windrow	↓		↓	

In anaerobic zones, however, plant-injuring substances, e.g., H_2S, may be formed. Thus it may happen that instead of the yield increase expected by the effect of the organic matter in such zones, the yield decreases and the plants are injured.

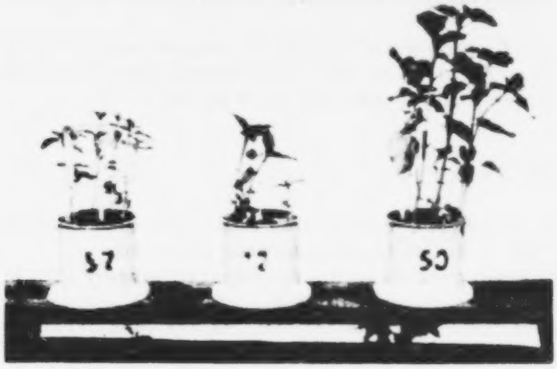


FIGURE 1: 52 unfertilized; 12 100 g D.M. anaerobic sewage sludge; 50 100 g D.M. aerobically composted sewage sludge

Table 2 lists the results of chemical investigations of comparable aerobic and anaerobic zones in sewage sludge from dry beds. The sample from Falkenberg contains relatively much sand and some ash, so that its values are considerably lower.

TABLE 2. Constituents of sewage sludge from upper aerobic and lower anaerobic zones

	Buch		Münchehofe		Falkenberg	
	aerobic	anaerobic	aerobic	anaerobic	aerobic	anaerobic
D.M., %	46.6	28.4	46.1	38.7	59.4	43.5
In D.M.						
Loss on ignition, %	60.3	65.3	62.0	59.9	10.1	34.9
Total N, %	2.42	2.84	3.14	2.66	0.51	1.16
NH_4-N, %	0.08	0.34	0.07	0.04	0.02	0.04
Total P_2O_5, %	1.23	1.09	1.96	2.60	0.50	0.60
Total K_2O, %	0.39	0.43	0.35	0.49	0.24	0.41

TABLE 3. Yields in Mitscherlich vessel after fertilization with sewage sludge from aerobic and anaerobic zones (tested plant: sunflower)

Sewage sludge sample, g	Yield per vessel, g D.M.	Difference, g PS (pure substance)	Relative	P %
Buch				
anaerobic	17,83		100	
aerobic	18,60	+ 0,77	104	77,5
Münchenhofe				
anaerobic	5,62		100	
aerobic	18,14	+ 12,52	323	0,10
Falkenberg				
anaerobic	10,30		100	
aerobic	14,97	+ 3,67	145	1,65

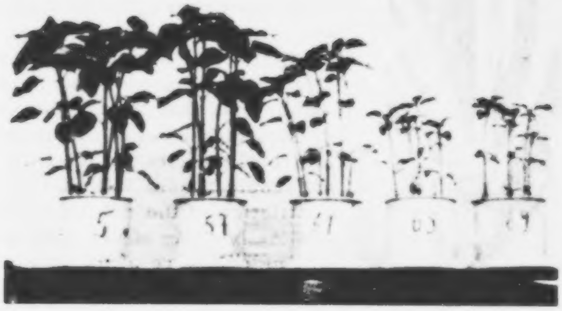


FIGURE 2. 5 = NPK; 57 = NPK + 50 g anaerobic sewage sludge (D.M.); 61 = NPK + 100 g anaerobic sewage sludge (D.M.); 65 = NPK + 200 g anaerobic sewage sludge (D.M.); 69 = NPK + 400 g anaerobic sewage sludge (D.M.)

TABLE 4. Effect of increasing doses of anaerobic sewage sludge in vessels sufficiently supplied with NPK

Fertilization per vessel	Yield g D.M.	Difference in comparison to unfertilized g D. M.	Relative
Unfertilized	3.24	–	100
NPK	10.56	+ 7.32	326
NPK + 50 g S.S (sewage sludge)	10.62	+ 7.38	328
NPK + 100 g S.S. (sewage sludge)	8.64	+ 5.40	267
NPK + 200 g S.S. (sewage sludge)	4.22	+ 0.98	130
GD 5%	2.25		69

The yields of the vessel experiments show that, independently of the variations, the sewage sludge from the upper aerobic zone is markedly better (200 g D.M. sewage sludge per vessel).

In a vessel experiment with sunflower and complete NPK (nitrogen phosphorus potassium) a continuous decrease in the yield was observed with added increasing doses of anaerobic sewage sludge (Figure 2).

Observations of floated refuse[2] on the Wernsdorf Lake (refuse flushing), where anaerobic zones had been formed at a depth of 10 – 30 cm, showed that the roots of plants over an anaerobic zone are deflected horizontally (Figure 3).

Thus, on one hand, direct damage can occur, while on the other hand, such plants have only a limited space for their roots.

Effect of Moisture on the Development of Anaerobic Zones

It is frequently assumed that the moisture level of the compost material is responsible for the development of anaerobic zones, but the moisture content is not the direct cause. Its effect is only indirect in that it deteriorates the ventilation conditions.

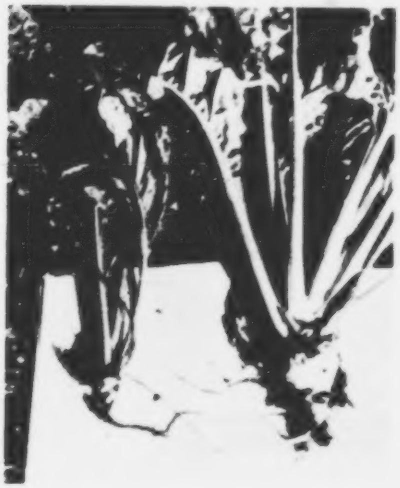


FIGURE 3. Horizontal deflection of sugar-beet roots over an anaerobic zone.

The example of spontaneous cleaning of rivers and seas, and also the biological purification of waste waters by the activated sludge process, show that aerobic decomposition of organic substances is possible even under water provided that oxygen is available.

Tests have shown that the moisture level of anaerobic zones is not necessarily higher than that of aerobic zones.

Moisture level of the compost material indirectly influences the formation of anaerobic zones, in that it changes the ventilation of the row by changing the bulk and the bedding of the compost rows.

The pressure of the compost material in the rows increases with increasing water level.

Drying the compost material can prevent the formation of anaerobic zones, but the water content optimal for the composting process must not be exceeded. This depends on the water capacity of the materials and also on the proportion of hygroscopic water, as well as exchangeable, hydration, and hydrate water.

TABLE 5. Moisture level of sewage sludge in a windrow with aerobic and anaerobic zones

Depth of windrow, cm	Zone	H_2O, %
	aerobic	
15		58.8
25	↓	59.1
35	anaerobic	60.2
45		57.1
55		61.5
64	↓	61.0

Thus in composting undigested sewage sludge, the formation of anaerobic zones could be inhibited by reducing the water level in sewage sludge below 50% /3, 4/. On the other hand, the biological decomposition of organic substances was inhibited too soon. The rows usually remained in the first mold stage. Overdried compost rows can be moistened only with difficulty by water introduced from the outside because such sewage sludge repels water drops.

TABLE 6. Changes in composts with moisture level

Compost from sewage sludge + refuse from market halls 2:1 Loss on ignition of D.M. = 38.0%		Compost from sewage sludge + refuse from market halls 1:2 + 5% ash Loss on ignition of D.M. = 30.3%	
H_2O %	Bulk weight kg/m^3	H_2O %	Bulk weight kg/m^3
31.5	445	23.0	578
34.8	461	26.7	–
37.7	475	30.0	579
40.4	495	33.0	605
42.9	514	35.7	622
45.2	546	38.4	662
47.3	557	40.8	696
49.3	582	43.0	760
51.1	613		
52.8	649		
54.3	677		

Factors Influencing the Formation of Anaerobic Zones

In addition to moisture content, several other factors exert a direct or indirect influence on the formation of anaerobic zones in compost rows. These are, for instance: the content of organic or decomposable organic matter; elasticity; bulk weight; size of the windrows; homogeneity; or content of bulky material.

The content of readily decomposable matter is decisive for the rate of the composting process: with increasing level of DOM (decomposable organic matter) microbiological decomposition and synthesis proceed faster Thus, the consumption of oxygen and the production of carbon dioxide are higher.

If the O_2 consumption is not compensated by adequate oxygen supply, and the increased amounts of CO_2 evolved are not drawn off simultaneously, oxygen deficiency sets in, and reduction zones are formed. The same effect may take place when the surface of the material is increased by crushing and mixing (hammer mills, screen graters, drums, etc.) so that the microbiological processes are intensified. Thus, it could be observed in Berlin that the refuse on vehicles of the Kuba type, in which the material is mixed in rotating drums and crushed to a certain degree, ferments much faster than in box-type vehicles without drums (such vehicles are no longer used).

Crushed refuse freed from bulky substance usually has a higher bulk weight. The pressure on the lower part of the window is greater, the material is pressed together to a higher degree, and the volume of the cavities is decreased. The elasticity of the material counteracts these effects; thus, crumpled paper refuse, for instance, can be compressed much less than vegetable refuse. Frequently in practice compost windrows consisting of vegetable refuse can be seen to shrink considerably within a very short time.

Possibilities of Preventing Anaerobic Zone Formation

Varying the size of the compost row can control the pressure on the lower layers of the windrows, and thus the ventilation, to a certain degree.

Condition of the Material

wet	dry
heavy	light
inelastic	elastic
crushed	uncrushed
without bulky material	with bulky material
high level DOM	low level DOM
small compost windrows	large compost windrows

There are limits to the size of the rows, however, especially the lower limits. With a smaller row, the warming decreases while the surface, external effects, and space requirements increase. When the height of the row exceeds 2 m, anaerobic zones will be formed even with favorable material, because the natural supply of air is not sufficient.

The air supply can be improved by frequent repiling, by having air channels at the bottom of the row, or by additional ventilation (blowing in or drawing off air).

All these steps involve a greater expenditure of work, energy, and material.

Stagewise Piling Method (SPM)

Using SPM can prevent the formation of anaerobic zones without additional expenditure of work. This method was developed and tested by the author in 1957 and 1958, and exhaustively described in 1961[4].

The principle of this method is based on the observation that anaerobic zones have a similar but smaller cross section than the row. When crushed sewage sludge was piled in rows 1 m high and 2 m wide with a 55 to 60% H_2O level, the anaerobic zones had a width of 80 cm and a height of 40 cm (Figure 4).

In the SPM, a part of the material to be composted is first piled in small rows 80 to 100 cm wide and 40 to 50 cm high. Molds develop strongly in these rows, and the temperature increases considerably.

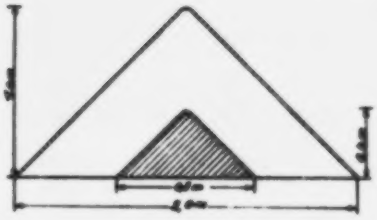


FIGURE 4. Dimensions of anaerobic zones in windrows of sewage sludge (50 – 60% H_2O) 1 m high and 2 m wide

The temperatures at a direct depth of 40 cm (measured from the top of the row) to the bottom of the row are slightly lower (about 10%) than the temperatures at a depth of 20 cm.

The abundant formation of mold mycelium increases the elasticity and decreases the compressibility of the row core. This process is similar to that designated in soil science as "biological blocking up" for stabilizing friable soil.

At the same time, the microbiological process which usually proceeds from the edge of the windrow to its interior is immediately started in its core.

After a large amount of mold mycelium has been formed and the temperature of the row has reached at least 25°C, the remaining material is piled up to the height desired.

In composting undigested sludge, a row 40 cm high and 80 cm wide, is advantageous for the first stage. A height of 100 cm, and a width of 200 cm is best for the second stage.

TABLE 7. Temperature (°C 20 cm below the surface) in windrows of crushed undigested sewage sludge 80 cm wide and 40 cm high

Days after piling	Average daily temp.	Windrow 1	Windrow 2	AT	Windrow 3	AT	Windrow 4
1	9.0	15.7	17.0	9.0	23.0	7.5	19.8
2	11.4	30.0	31.0	7.5	25.0	5.6	–
3	15.1	45.0	45.7	–	–	5.4	–
4	15.2	46.7	49.0	–		4.8	53.5
5	16.4	49.0	52.0	–	–	5.5	47.7
6	8.4	48.0	–		–	6.1	39.9
7	9.1	46.7	–	–	–	8.5	–
8		–	–	–	–	10.2	40.5

If, for reasons of space, larger rows are required, they should be piled in 3 or 4 stages. In such two- or multiple-stage rows, the temperature increases especially rapidly because the rows are "heated" from the core and infected with thermophilic microorganisms.

In all the rows we set up, the temperature increased to 55 – 65°C within a day.

Using SPM, the formation of anaerobic zones can be reliably prevented without an increase in the work expenditure necessary for row composting.

The more rapid temperature increase is followed by a more rapid temperature decrease, which also leads to the conclusion on acceleration of the composting process.

SPM should be employed especially in cases where it is important to prevent the formation of anaerobic zones and increase the composting process in rows without additional expenditure.

Summary

1. SPM (stagewise piling method) was developed by the author in 1957 and 1958 and tested in composting undigested sewage sludge.

2. Anaerobic zones are most disadvantageous for both the composting process and plant growth.

3. Formation of anaerobic zones is only indirectly influenced by the H_2O level in the rows.

4. The level of organic or decomposable organic matter, elasticity, bulk weight, homogeneity, or content of bulk matter influence the formation of anaerobic zones directly or indirectly.

5. In SPM (stagewise piling method) small rows are set first, and larger rows are piled on them.

SPM prevents the formation of anaerobic zones, leads to a very rapid temperature increase, and accelerates the composting process.

Bibliography

1. **Baumann, E.** Modellversuch zur Kompostierung bei unterschiedlicher Belüftung (mittels Tondranagerohren bzw. Kanalen sowie Zuschlagstoffen) (Model Experiments on Composting with Different Ventilation (Using Ceramic Drainage Pipes or Channels, and Additional Substances)).— Dissertation, Berlin, 1958.
2. **Bohme, L.** Müllverspülung am Wernsdorfer See (Refuse Spilling on the Wernsdorf Lake).— Wasserwirtschaft-Wassertechnik, Vol. 5, pp. 194—196. 1955.
3. **Bohme, L.** Kompostierung von Klärschlamm nach dem Verfahren der "Natürlichen Kompostierung" (Composting of Sewage Sludge According to the "Natürliche Kompostierung" Process (Composting under Natural Conditions)).— Die Deutsche Landwirtschaft, Vol. 8, pp. 615—616. 1957.
4. **Bohme, L.** Fragen der Kompostierung von nicht ausgefaultem Klärschlamm (Problems of Composting Undigested Sewage Sludge).— Dissertation, Berlin. 1961.
5. **Straub, H.** Herstellung von Kompost aus Faulschlamm und Hausmull nach dem Verfahren Baden-Baden. Probleme der Siedlungsabfallwirtschaft. (Production of Compost from Digested Sludge and Domestic Refuse According to the Baden-Baden Process. Problems of the Waste Disposal in Housing Areas).— Paper on the Subject: Utilization of Sewage Sludge and Domestic Refuse. 1954.
6. **Straub, H.** Das Kompostwerk Baden-Baden (The Composting Plant in Baden-Baden).— Das Gas- und Wasserfach, Vol. 95, Issue 12. 1954.

FURTHER HYGIENIC INVESTIGATIONS ON THE INFLUENCE OF "PROMOTING OR STIMULATING FACTORS" ON DECONTAMINATION OF REFUSE- AND SEWAGE-SLUDGE COMPONENTS

By Dr. D. Strauch, Institut fur Hygiene und Infektionskrankheiten der Tiere der Universität Giessen
(Director: Professor Dr. F. Ulbricht)

In municipal enterprises which process solid or solid plus liquid domestic refuse, attempts are made to accelerate the fermentation process in order that a higher yield of compost may be obtained on the available areas. The compost producer also desires to retain the organic matter as far as possible. Many authorities recommend the addition of "promoting and stimulating substance" to the compost before piling it into rows, or during the composting process as a way to accelerate fermentation.

In a previous publication we reported experiments in which the effect had been tested of some promoting factors on the killing of pathogenic germs. The investigations were performed in the composting plants at Baden-Baden and Bad Kreuznach. The preparations tested were "Edafil," "Proteg-Oleo," and a mixture known as "Zusatz Frankfurt." We concluded that the three promoting substances are not really necessary as far as the problem of decontamination is concerned. On the other hand, treatment of compost with these substances is not harmful from the hygienic viewpoint if it is desired to apply them to improve the compost (Strauch, 1964).

We also had occasion to investigate in the composting plants at Heidelberg and Bad Kreuznach other additives for their hygienic effects: this will be the subject of this article.

Materials and Methods

The composition of these additives which are sometimes designated not quite correctly by their producers as "promoting substances" cannot be determined in most cases because the producers give no informative data. In our investigation, two different preparations were used.

1. "Multibacto": This is Earp-Thomas Preparation No. 1, and, according to data given by the producer, it contains bacteria which promote fermentation during the composting process.
2. "B. D.-Starter": This preparation has been developed by Pfeiffer (1957) in the U. S. A. It also consists of microorganisms, not specified, which should have a favorable influence on fermentation.

For our experiment in Bad Kreuznach, six rows were made from prefermented compost of the DANO-biostabilizer with 10% sewage sludge. Each row was provided with thermocouple on a certain measuring point, and a hose in order to determine the gas formation. To each measuring point were applied four bags containing material of which the row was made up, and which was infected with a suspension of anthrax bacilli. In the experiment in Heidelberg, a closed ampule with a pure culture of anthrax bacilli was added into each bag. During repiling after 15, 28, and 50 days, as well as on termination of the experiments (97 days), a bag was taken to the laboratory and analyzed for living anthrax bacilli. Two rows were treated with the same additive, and the last two rows were untreated, serving as controls.

More detailed information on relevant literature and the bacteriological investigation methods applied is reported elsewhere (Strauch, 1964). Details on the composition of the compost rows, their structure, water level, and gas analyses are here omitted to save space. They are contained in the publication by Farkasdi (1963), and also in a report of the "Arbeitsgemeinschaft Giessener Universitatsinstitute" (Working Group of the University Institutes of Giessen) to the Federal Ministry of Health; interested readers are refered to these two papers.

In Heidelberg, the bags were taken after 14, 29, 51, and 102 days. Two untreated rows served as controls for the experiments in which Multibacto was added, while one untreated row was available for control of the preparation B. D.-Starter. Also in Heidelberg, an untreated control, designated as Row 8, was provided with 9 measuring points; in measuring points 1 — 7 aerobic conditions prevailed, while the conditions in points 8 and 9 were intentionally anaerobic. These rows were also used for detailed determination of the lethal time [of the anthrax microbes], and were much larger than the conventional rows.

Results

1. Bad Kreuznach

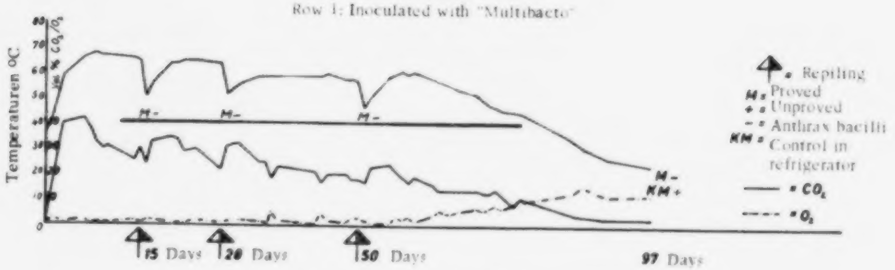
As shown in Figures 1 — 3, anthrax bacilli could not be observed in all the measuring points in the compost material of the sample bags as early as 15 days up to repiling of the rows. No differences between the treated rows and the untreated controls could be established. When the curves for the individual compost rows are visually compared, no considerable differences are seen between the temperature and gas values of the differently treated rows or the untreated controls. This applies to the behavior of the anthrax agents, and temperature and gas curves. Thus, the temperature and gas formation curves, as well as other physical, chemical, and biological tests (Farkasdi, 1963) show no effects of the promoting substances on the composting process and the hygienic state of the rows.

2. Heidelberg

The compost of the Heidelberg plant at the time of the investigation was produced from pure municipal refuse (rasped material) without any addition of sewage sludge. In principle, the experiment was set up in the same manner as in Bad Kreuznach. The samples were taken and the rows repiled after 14, 29, and 51 days, and the experiment was terminated after 102 days. Figure 4 represents the results of the treatment with "Multibacto." It can be seen here, also, that no difference was established between treated and untreated rows. This applies both to the temperature curves and killing of the anthrax bacilli. The only fact which could be established was that anthrax bacilli sealed in the ampules succumbed to the influence of the environment later than the natural germs introduced into the material. This is confirmed by the earlier observation of Strauch that in compost rows, certain inhibiting factors in addition to thermal effects promote the inactivation of pathogenic agents. The same observations were made in the experiments with the "B. D.-Starter"; it must be emphasized here, however, that during the decreasing temperature stage after the third repiling, the temperatures in the untreated controls were between 10 and 15°C higher than in the treated rows.

With both preparations used, the anthrax bacilli were killed within a fortnight. Later samples taken after 29, 51, or 102 days did not contain any living anthrax agents.

Bad Kreuznach
Experiment II
Row 1: Inoculated with "Multibacto"



Row 2: Inoculated with "Multibacto"

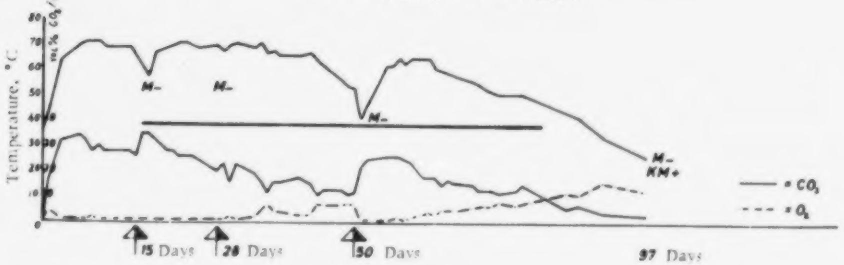
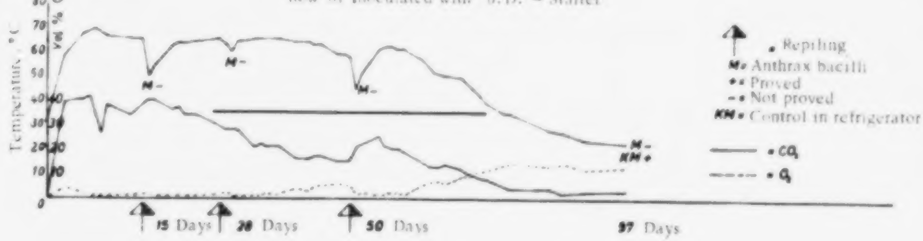


FIGURE 1. Experiments with promoting substances: results of temperature measurements, gas analyses, and bacteriological tests

Bad Kreuznach
Experiment II
Row 3: Inoculated with "B.D. – Starter"



Row 4: Inoculated with "B.D. - Starter"

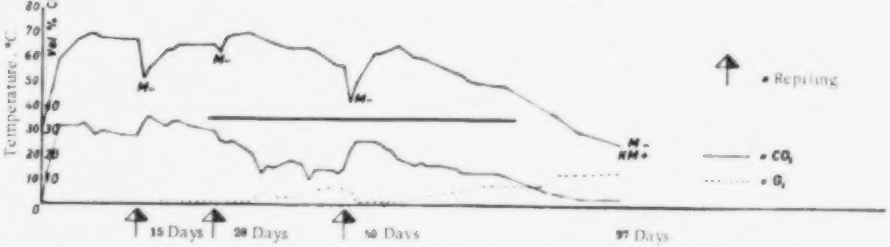


FIGURE 2. Experiments with promoting substances: results of temperature measurements, gas analyses and bacteriological tests

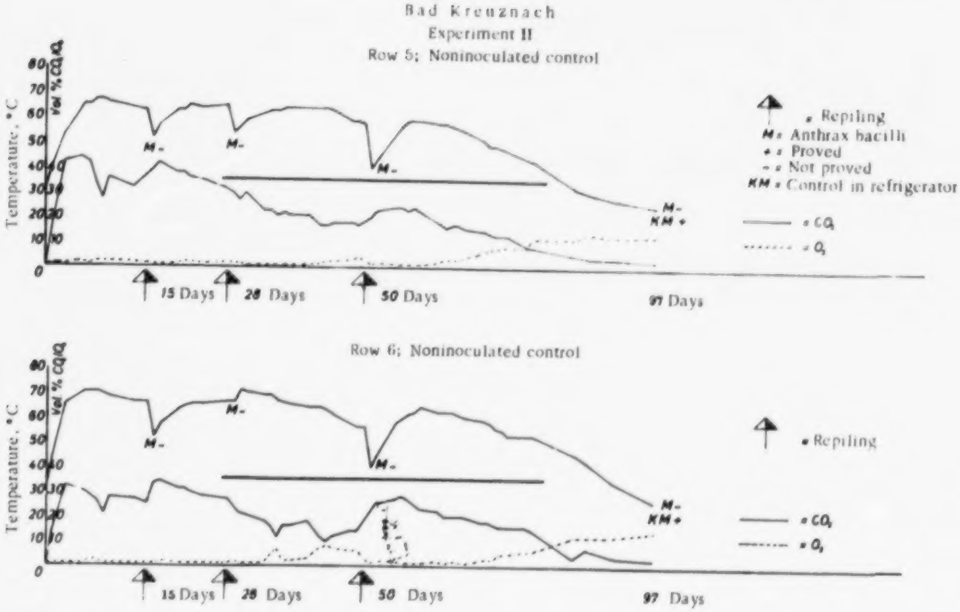


FIGURE 3. Experiments with promoting substances: results of temperature measurements, gas analyses, and bacteriological tests

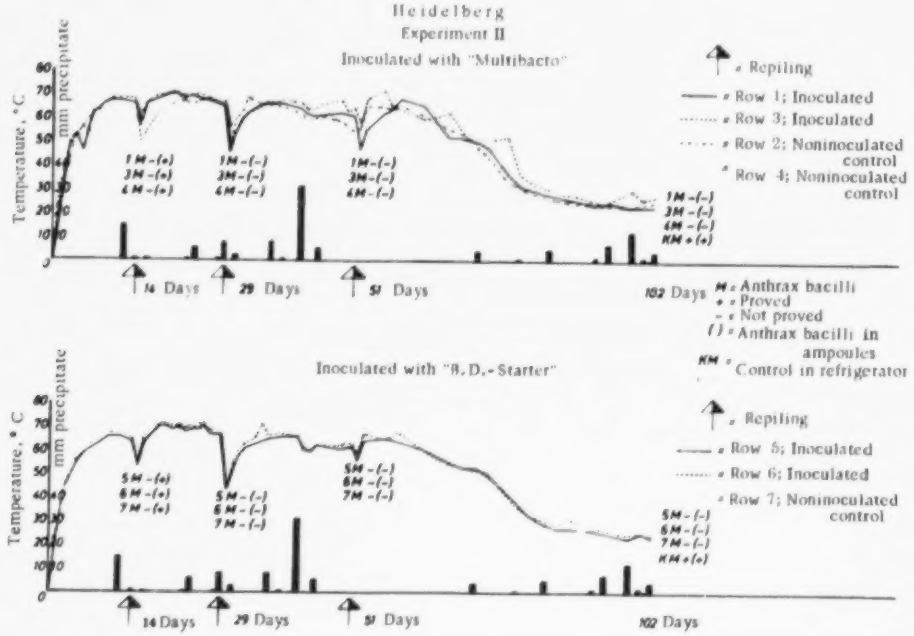


FIGURE 4. Experiment with promoting substances; results of temperature measurements and bacteriological investigations

Row 8, which was untreated and not repiled, was provided with 9 measuring points, into some of which several bags with anthrax bacilli were inserted (Figure 5). In Figure 6, the average temperatures of the measuring points 1 – 3 or 4 – 7 are shown. At these measuring points, aerobic conditions prevailed, while measuring points 8 and 9 were purposely made anaerobic by an abundant water supply. A comparison of both temperatures showed that in the aerobic region they always average 10°C higher than the range in the anaerobic region. The results of the bacteriological tests show an agreement with this observation. In the aerobic region, the anthrax bacilli lived for a longer time than in the aerobic rows. They were found to live as late as after 50 – 70 days on one site in the compost and in all the glass ampules. Only after 102 days were the germs killed in both the compost and the ampules. In composting rows, therefore, care must be taken that the process proceeds under aerobic conditions because only then can a hygienic final product be attained.

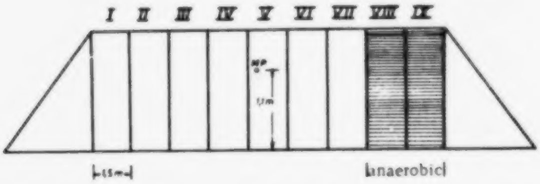


FIGURE 5. Heidelberg, experiment III: structure of row 8 (MP = measuring point).

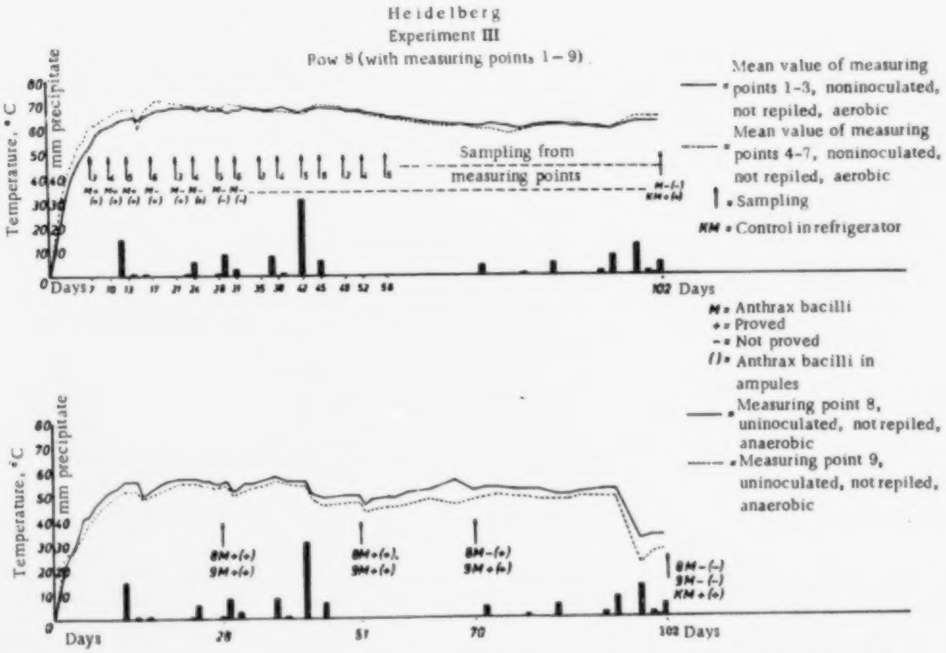


FIGURE 6. Experiment with promoting substances; results of temperature measurements and bacteriological tests

It was established in our previous investigations (Strauch 1964) in Heidelberg that on composting municipal refuse, the anthrax bacilli which were introduced lived even after 21 days while in the rows of Baden-Baden and Bad Kreuznach, they were killed in this time interval. In the present investigation, these observations were not confirmed. As can be seen from Figures 4 and 6, the anthrax bacilli were also killed after 14 days in the uninoculated control rows 4 and 7. In order to determine the precise period of killing, row 8 was built (Figures 5 and 6), and no promoting substance was added. Sampling was carried out from this row in shorter time intervals (see Figure 6, top diagram). The experiment showed that living anthrax bacilli could be found in the compost on the 13th day; in the sealed glass ampules they lived up to 24 days. The difference in killing time of the anthrax agents is further proof of the presence of inhibiting substances mentioned earlier. The experiments confirmed that in Heidelberg, as well as in Baden-Baden and Bad Kreuznach (taking into account a safety margin of one week), a hygienic final product, including the destruction of spore-forming pathogens, can be achieved. The fact that pathogenic organisms from the intestines, e.g., the agent of paratyphus, can be killed within 3 weeks in row composting municipal refuse was proved by Knoll (1963). According to investigation, killing of such organisms is guaranteed after at least 10 days when a temperature of 56 – 65°C is maintained in the rows.

The long lifetime of anthrax bacilli in the Heidelberg experiments may be explained by the relatively low temperatures of the rows at that time (Strauch 1964, Page 76, Table 6). If we compare these temperatures with the temperatures shown in Figures 4 and 6, it is easy to see that the temperatures in the present experiments were much higher than in the earlier ones. It is possible that these were determined by different moisture levels in the initial material which may be correlated to a lower biological activity; the production of inhibiting substances decreased with decreasing moisture level.

Summarizing the results of the two-year experiments with the inhibiting substances, we concluded that the application of Edafil, Proteg-Oleo, Zusatz Frankfurt (Strauch 1964) and Multibacto and B. S.-Starter offers no advantages in row composting; the hygienic conditions of the conventional refuse compost or sewage sludge compost are just as good when composted without such additives. From the viewpoint of hygiene, no promotion substances are needed in composting.

So far as the practical side of refuse composting is concerned, the application of additives in row composting is useless, or at least uneconomical (Obrist 1963). According to Farkasdi (1963) this statement, however, does not apply to the possible utilization of nutrient or promoting substances in composting industrial refuse (the composition of which is very one-sided, and the germ content low), or inoculating raw compost with fermented compost; some plants allegedly obtained good results with the latter method. The conditions probably differ in compost rows with fermentation cells where the aim is rapid composting. In such cases, addition of nutrient substances could be of some importance. Since no investigations of this problem have been made to date, we cannot decide on this question.

Summary

Hygienic-bacteriological investigations on the application of promoting or stimulating substances in row composting refuse, with or without sewage sludge, have shown that such additives have no importance for decontaminating the compost. If, on the other hand, an application of such additives is desirable or necessary for other reasons, no objections can be raised from the hygienic point of view as these additives neither improve nor deteriorate the hygienic conditions of the compost.

Bibliography

Arbeitsgemeinschaft Giessener Universitäts-Institute. Bericht über die Ergebnisse von Kompostierungsversuchen mit Zusatz von Impf- bzw. Förderstoffen, erstattet an das Bundesministerium für Gesundheitswesen, Giessen 1963 (Report on the Results of Composting Experiments with Addition of Promoting or Inhibiting Substances, Submitted to the Federal Ministry of Health Giessen 1963).

Farkasdi, G. Versuche über die Wirkung verschiedener Zusatzstoffe bei der Mietenkompostierung von Müll und Klärschlamm (Experiments on the Effect of Various Additives in Raw Composting Refuse and Sewage Sludge). — Internationale Arbeitsgemeinschaft für Müllforschung, Informationsblatt No. 19, p. 17. 1963.

Knoll, K. H. Neuere Methoden der Abfallbeseitigung unter besonderer Berücksichtigung der Abtötung von Salmonellen (Recent Methods for Waste Disposal with Special Regard to Killing Salmonellae). Inaugural Dissertation, Giessen 1963.

Obrist, W. Versuche über die Wirkung von Zusatzstoffen bei der Mietenkompostierung zerkleinerter häuslicher Abfallstoffe (Experiments on the Effect of Additives in Row Composting Crushed Domestic Waste). — Internationale Arbeitsgemeinschaft für Müllforschung, Informationsblatt No. 19, p. 23. 1963.

Pfeiffer, E. Anteilung für die Kompostfabrikation aus städtischen und industriellen Abfällen (Introduction to Compost Production from Municipal and Industrial Waste). Verlag Gustav Fischer, Stuttgart, 1957.

Strauch, D. Veterinärhygienische Untersuchungen bei der Verwertung fester und flüssiger Siedlungsabfälle (Veterinary-Hygienic Investigation in Utilizing Solid and Liquid Municipal Refuse). — Schriftenr. a. d. Geb. d. öff. Ges. Wesens, Issue 18, Verlag Georg Thieme, Stuttgart. 1964.

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BOOK REVIEW

Walter Liese: Gesundheitstechnisches Taschenbuch (A Concise Manual of Sanitary Engineering), R. Oldenbourg-Verlag, München-Wien, 1964. 226 pages, 105 Figures, 104 Tables, 12 Appendices. DM 28.—

This manual, intended for the practical technician of environmental hygiene and the expert in research and administration, contains information on the tasks of the main fields of sanitary engineering. The information is concise and accurate, and is supplemented with a large number of instructive figures and tables.

The author intentionally did not give an exhaustive textual treatment of the individual chapters, but the book contains a large amount of data, in figures and diagrams, thus retaining the character of a concise manual. The book offers bibliographic references for the reader interested in further information, and the objective references to suppliers will be a great help for the technician in practice.

The articles on air, waste water, and refuse alone make the book a valuable supplement to the Imhoff, or AkA-Reference Book and Refuse Manual. The book is an encyclopedia for the expert in sanitary engineering who wants rapid, concise, and exhaustive information.

ANNOUNCEMENTS OF THE SECRETARIAT

New State Group of the IAM in Austria

We are pleased to announce that the Austrian Wasserwirtschaftsverband (Union for the Utilization of Water) under the direction of its manager Dr. R. Bucksch, has decided to officially represent the IAM in Austria. We are convinced that a fruitful cooperation among the experts of other countries and their Austrian colleagues is thus initiated. We ask persons interested and subscribers of the Information Bulletin IAM to contact the following address in matters of the IAM events:

Oesterreichischer Wasserwirtschaftsverband, Graben 17, Wien I.

EVENTS

1) Refuse Engineering Seminars at the Technische Hochschule, Stuttgart

10th seminar on 14 January 1966, 10 – 17.30 hrs.

Topic: Practical Examples of Preliminary Investigations and Planning of Plants for Refuse Disposal. Chairman: Prof. Dr. Ing. E. h. Kumpf.

11th seminar on 11 February 1966, 10 – 17.30 hrs.

Topic: Special Problems of Disposal of Solid Industrial Refuse. Chairman: Prof. Dr. Ing. habil. Pöpel.

Both seminars take place in the large auditorium of the temporary auditorium complex HP 1, Max-Kade-Weg .

2) International Exhibition of Municipal Equipment in Nancy (France)

An international exhibition of municipal equipment will be held in Nancy from 2 to 8 May, 1966. It is under the auspices of the Minister of the Interior and the Union of the Mayors of France. This exhibition will present a survey on the latest technical achievements in the field of public sanitation (water supply, waste water purification, street cleaning), housing, noise prevention, prevention of air pollution, etc. Within the framework of this exhibition, the National Congress of the Union of French Municipal and Communal Engineers and the National Union of Municipal Hygienists will hold 2 days of study. For further information and entry forms apply to: Salon international de l'équipment urbain, B.P. 539, Nancy, France.

3) Federal Congress of the Union of Municipal Transport and Public Cleansing Services (VKF) in Berlin

At the end of June 1966, the Federal Congress of the VKF will take place in Berlin.

For more information apply to: Verband Kommunaler Fuhrparks- und Stadtreinigungsbetriebe, Weidenbornstrasse 40, 6000 Frankfurt a/M.

4) INTAPUC Congress in Paris

The International Association of Public Cleansing (INTAPUC) will hold its 9th International Congress on 26 – 30 July, 1967.

5) IAM Congress in Switzerland

The Executive Committee of the IAM decided at its last meeting to hold its 4th International Congress in Switzerland, probably Basle (Spring 1969).

INFORMATION BULLETIN NUMBER 26
April 1966

DETERMINATION OF THE QUALITY OF INCINERATION OF ASH AND CLINKER FROM WASTE-INCINERATION PLANTS

By G. Rollé, EAWAG, Zurich

A characterization of the ash and clinker from waste-incineration plants concerning the degree of incineration is in principle desirable. The residue of unburned decomposable organic matter (DOM), or of the so-called "fermentable matter," provides information on the quality of the combustion. This value is also mentioned in the guarantees given by some firms producing furnaces. In general, in Europe, as complete incineration as possible, i.e., a small residue of unburned DOM, is sought and often guaranteed by the firms. In the U.S., however, the tendency is to obtain reduction of volume without stressing maximum incineration. This is also a question of the possibility and methods of dumping, because a certain content of fermentable matter may cause nuisance of odor or vermin.

In general, it may be stated that the degree of incineration (which ultimately is also a question of economy) has not the importance attributed to it in the past and sometimes even today. It is not very likely that groundwater will be polluted by decaying components of combustion residues, because a biological decomposition process is at all events greatly impeded in the alkali environment poor in nutrients. Groundwater is more likely to be affected by eluted inorganic salts. It seems that the inorganic component is chiefly to be blamed if groundwater is polluted by refuse dumps, where DOM is contained in large quantities.

From an aesthetic point of view, still recognizable refuse components such as parts of fruits and vegetables, scraps of paper, etc., are not desirable. In addition, superficial fermentation may occur, attracting vermin and producing unpleasant odors.

Since the quality of incineration is under discussion, we must try to determine this value reliably. Several methods of analysis were suggested but they were not completely satisfactory, e.g.,

— loss on ignition (according to DIN standards for solid fuel). This method is suitable only conditionally, at best it yields approximate values for assessing the degree of incineration, because in principle it comprises the entire unburned part (including carbonate-CO_2 and C which is not bound to DOM).

— EMPA (Eidgenossische Materialprufungsanstalt [Swiss Federal Institute for Testing of Materials]) modified a method of TIRU (Traitment Industriel des Résidus Urbains, Paris). The proportion of the combustion residues soluble in lye is determined and from this the content of unburned DOM is assessed. But this is only possible conditionally, because in this case too, carbon-containing compounds are included, which are indecomposable or can be decomposed only with great difficulty.

— The TUV (Technischer Ueberwachungsverein [Institute of Technical Supervision]) Dusseldorf uses a method that yields lower values than the above-mentioned methods. Details of the anlaysis and its results are not known to us.

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Since the unburned organic matter is a heterogeneous mixture of various compounds, the first consideration is, what should be handled chemically and how it should be determined. The most obvious course seems to be to try to determine the carbon content. However, this C-content must derive exclusively from DOM. Carbon, e.g., from unburned coal in the wider sense, must not be included because in the case of biological decomposition it has no effect. This is known by the expression "C in DOM," which is a value for the quantity of unburned decomposable organic matter contained in the combustion residue.

An attempt was made to deal chemically with this "C in DOM" in a simple way and to determine it.

Finally, based on experience with the determination of DOM in refuse and refuse compost, a titrimetric oxidation method was worked out, which is quick and, as many tests of clinker prove, yields reliable and reproducible values of "C in DOM."*

Based on this EAWAG method, the quality of incineration in the form of C in the unburned DOM can be expressed by a number. The critical range of C-content is to be found by the examination of refuse clinker and ash directly from plants and dumps, especially in the hot season. Several results of examinations of ash and clinker are tabulated below; they were obtained by a method proposed in the following contribution of this IAM issue. The samples were taken from different waste incineration plants and their dumps.

Plant/Dump	C_{DOM} in the clinker	C_{DOM} in the fly ash
A	1,9 2,1 2,9 3,5 3,6	-
B	1,2 1,3 1,6 1,9	0,3 0,8 1,5
C	2,7 4,1 7,0	-
D	3,9	-
E	1,2 1,4 2,1	0,12 0,29
F	3,3 4,7 5,2 5,3 5,4	5,4
G	1,2 1,3 1,7 11,0	-
H	1,2 1,4	-
I	4,1	-

The figures show that the quantities of "C in DOM" lie mostly between 1 – 4% of the dry, ground and homogenized clinker samples. These are the first investigations in connection with the development of this method. In future, more research will have to be carried out, for, on the one hand, the stored clinker has to be of a quality that does not cause any nuisance; on the other hand, with regard to the economy of incineration and ashing of the refuse, the demands on the quality of incineration must not be unreasonably high.

It is evident that the proposed method may make it possible to determine simply, quickly and reliably the quality of incineration in regard to the carbon content in unburned decomposable organic matter. However, practice and experience have to show now what upper limits and tolerances should be stipulated. Together with the proposed chemical method, biological investigations must help find them.

Considering this state, it seems reasonable to stipulate a "C in DOM" content of 2.5% with a tolerance of 1%. Perhaps, in the course of time, this value should or could be corrected downward or upward. No doubt usages will be established that will allow for differences in individual dumps, within the tolerance limits.

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* When interpreting the results, it has to be taken into consideration that the known methods of taking samples may show considerable scatter.

METHOD FOR THE DETERMINATION OF CARBON OF DECOMPOSABLE ORGANIC MATTER IN REFUSE CLINKER

By Dipl. Ing. chem. Bogdanka Orsanic, EAWAG, Zurich

1. Introduction

1.1 Definition of the problem

Combustion is a method of refuse disposal resulting in clinker as the final product which, in most cases, has to be dumped. After good combustion, the clinker should contain, besides mineralized inorganic matter, the smallest possible amount of organic components. If the combustion is not complete, the clinker may contain considerable quantities of organic matter (unburnt residues of wood, paper, vegetables, plastics, etc.). These may be divided into so-called decomposable organic matter (DOM) and into resistant organic matter (ROM) /1/.

In districts in which households are heated mainly by coal, especially bituminous coal or coke, the clinker may contain unburnt coal in considerable quantities.

The clinker resulting from the combustion is slaked by water (clinker bath). The oxides of lanthanides and alkali metals are dissolved, and the pH value may consequently increase to more than 10. When dumped the clinker is gradually infected by the environment. If there are large quantities of unburnt DOM, different decompositon reactions occur, whereby the DOM is completely decomposed. It forms a nutritive soil for different aerobic and anaerobic microorganisms. ROM (rubber, plastics, etc.) and coal, possibly present, are of lesser importance for the microbiological decomposition because of their resistance. Since DOM may raise certain questions when the clinker is dumped, its quantity has to be determined. This may also be of importance in evaluating incineration plants.

For these reasons it is necessary to work out for these very complicated and complex problems of clinker dumping an analytical method making it possible to detect small quantities of DOM in the clinker without simultaneously determining the other carbon compounds (ROM, carbonates, carbides, elementary carbon from coal, etc.).

In this paper such a method is described. The inorganic water-soluble compounds are very important as clinker components. But this problem is not dealt with in this context.

1.2 Discussion of the literature

Oxidation of the soil for determining organic matter was formerly carried out by dry combustion which was gradually replaced by wet combustion.

Wet combustion is very simple and quick. Schollenberg /2/ recommended wet combustion as early as 1927. In time this method was further developed.

Rauterberg and Kremkus /3/ oxidize with dichromate potassium ($K_2Cr_2O_7$) and hydrolyze with H_2SO_4 and H_3PO_4. A sufficient known amount of ferrous ammonium sulfate ($FeSO_4 \cdot (NH_4)_2 SO_4 \cdot 6H_2O$: FeAmS) is added to the residual $K_2Cr_2O_7$, and the excess is backtitrated by $K_2Cr_2O_7$, with diphenylamine as indicator.

Springer and Klee /4/ carried out the oxidation at a higher temperature and with-within a shorter time.

Kurmies /5/ bactitrates the excess of Fe-salt with $KMnO_4$ without indicator.

Simakov /6/ recommends N-phenylanthranilic acid as indicator.

Mebius /7/ examined wet combustion of soil according to Simakov and compared the results with the corresponding results of dry combustion. He found good agreement.

2. Experiments

Several methods /3, 4, 7) of determining organic matter in soils with $K_2Cr_2O_7$ were tested. The following method /7/ was found suitable:

The substance is heated with a solution of $K_2Cr_2O_7$ and sulfuric acid on a sand bath at 160°C. The excess $K_2Cr_2O_7$ is titrated directly with a FeAmS solution and with N-phenylanthranilic acid as indicator.

This method was originally worked out for the determination of organic matter in soil, but it was not suitable for the determination of carbon in the DOM of clinker. It was, however, used as a basis for such a determination, and in a series of experiments the exact conditions for the application of this method for the determination of "C in DOM" of the clinker were elaborated.

These conditions are:

2.1 Temperature and time of reaction of H_2SO_4 and $K_2Cr_2O_7$ on the sample
2.2 Specificity of the method
2.3 Optimum ratio: quantity of sample to quantity of $K_2Cr_2O_7$
2.4 Decomposition of $K_2Cr_2O_7$ at elevated temperature.

2.1 Temperature and time of reaction of H_2SO_4 and $K_2Cr_2O_7$ on the sample

When the reaction temperature was examined, the samples were

2.1.1 heated on a sand bath
2.1.2 heated on a water bath
2.1.3 not heated; the elevated temperature is caused only by the heat of reaction.

TABLE 1. Influence of temperature and time in the reaction of H_2SO_4 and $K_2Cr_2O_7$ on graphite

No	Time min	Temperature, °C	% C as C_{DOM}	Remarks
1	10	Sand bath	1,8	C_{elem} in graphite = 92.9%
2	15	–	3,6	
3	20	–	4	(Analysis performed according to /10/)
4	30	–	7,5	
5	45	–	15	
6	60	Boiling water bath	0	
7	120	–	0	
8	60	Not heated	0	
9	120	–	0	

Saccharose and graphite were used as the test substances; first the total quantity of carbon (C_{elem}) was determined. Then carbon as C in DOM (C_{DOM}) was determined. The tests were performed simultaneously with different reaction times of H_2SO_4 and $K_2Cr_2O_7$. The results are contained in the following Tables and Figures (Tables 1 and 2, Figures 1 and 2).

TABLE 2 Influence of temperature and time in the reaction of H_2SO_4 and $K_2Cr_2O_7$ on saccarose

No.	Time, min	Temperature, °C	% as C_{DOM}	Remarks
1	15	Sand bath 150 – 160°	43	C in saccarose = 42,18
2	20	"	43,2	(Analysis performed in Org. Chem. Micro-Labor. ETH [Federal Technical University])
3	30	–	43.3	
4	45	–	43.7	
5	60	Not heated	38.6	
6	90	–	39	
7	120	–	39.8	
8	60	Boiling water bath	42.15	
9	90	–	42.18	

From these results it is evident that the most favorable conditions for the determination of C_{DOM} are obtained by heating the sample on a water bath, because all the C_{DOM} can be determined without inclusion of C_{elem}.

To test this finding further, appropriate determinations of C_{DOM} were carried out with filter paper, cellulose powder and starch. The results are contained in Table 3.

TABLE 3

No.	Material	Time, min.	Temperature	% C_{DOM}	Remarks
1	Filter paper Schleicher-Schuell-Blauband	60	Boiling water bath	42,18	Used: 0,030 g sample + 30 ml 0.267 N $K_2Cr_2O_7$
2	Starch Difco Certified sol. Starch	60	–	42,20	
3	Cellulose powder "Whatman"	60		42.18	

The results confirmed the above-mentioned assumption.

To test reaction time further, determinations were carried out with different reaction times with 2 samples of refuse clinker (Nos. 1 and 2, Figure 3).

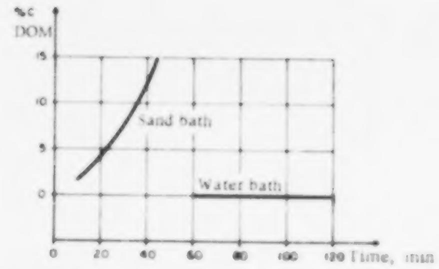


FIGURE 1. Graphite

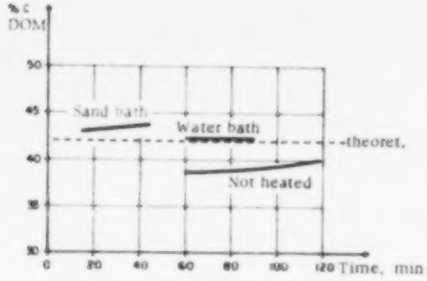


FIGURE 2. Saccharose

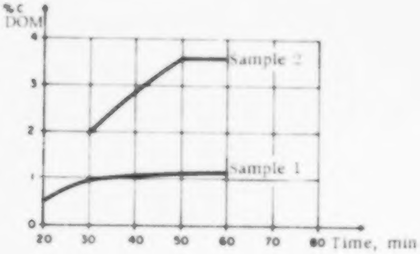


FIGURE 3

2.2 Specificity of the method

This method should be highly specific, i.e., the total C_{ROM} should be determined, but no C_{elem} and C_{ROM}. The specificity of the method, as far as C_{elem} is concerned, was already determined in the tests 2.1.2 (Table 1).

In order to examine the specificity of the method in relation to C_{ROM}, C (corresponding to C_{ROM}) was determined in polyethylene (finely ground, or in lozenges) and in Vinoplex 626 BASF (Table 4).

TABLE 4

No.	Material	Time, min.	Temperature	$\%C_{DOM}$	Remarks
1	Polyethylene - finely ground	60	Boiling water bath	2,4	Used: 0,300 g sample + 30 ml 0,267 $K_2Cr_2O_7$
2	Polyethylene - lozenges	60	"	0,5	
3	Vinoplex 626 BASF	60	"	0,6	

The quantity of C_{Rom} detected by this method is so small that it may be neglected, especially since there are no fixed boundaries between DOM and ROM in actual practice.

2.3 Optimum ratio: quantity of sample to quantity of $K_2Cr_2O_7$

To test the influence of the ratio quantity of sample to quantity of $K_2Cr_2O_7$, a number of determinations were carried out, in which the increasing amounts of refuse clinker were treated with a constant quantity of $K_2Cr_2O_7$ (30 ml 0.267 N) (Table 5).

TABLE 5.

No.	Material	Quantity of sample, g	FeAmS-0,2N ml	% C_{DOM}
1	Refuse clinker 3	0,100	5,25	3,15
2	"	0,200	10,5	3,15
3	"	0,300	15,5	3,10
4	"	0,400	20,6	3,09
1	Refuse clinker 4	0,100	1,65	0,99
2	"	0,200	3,3	0,99
3	"	0,300	4,95	0,99
4	"	0,400	6,6	0,99
5	"	0,300	8,25	0,99

The results of these determinations show very good agreement when the difference between the number of ml of FeAmS consumed for the sample and the blank test is not greater than 11 ml. If the content of C_{DOM} is 1.5-8%, 0.1-0.5 g samples may be used for the analysis. If the C_{DOM} content is greater than 8%, the sample quantity may be correspondingly less than 0.1 g.

The same results are obtained if double amounts of sample and $K_2Cr_2O_7$ are taken.

2.4 Decomposition of $K_2Cr_2O_7$ at elevated temperature

Possible decomposition of $K_2Cr_2O_7$ at elevated temperature was examined. Ten ml $K_2Cr_2O_7$ were titrated with an FeAmS solution till the color changed (indicator N-phenylanthranilic acid).

The $K_2Cr_2O_7$ solution was

2.4.1 titrated directly without heating,

2.4.2 first heated for 1 hour on a boiling water bath, cooled, and then titrated (Table 6).

TABLE 6.

No.	ml FeAmS: without heating	ml FeAmS: after heating
1	13.99	13.98
2	13.98	13.97
3	13.98	13.99
4	13.99	13.99
5	13.98	13.98

Almost no differences could be determined. The elevated temperature applied in the analysis consequently does not cause any decomposition of $K_2Cr_2O_7$.

3. Method of determining C_{DOM} in refuse clinker

On the basis of preliminary tests described the most suitable conditions for the determination of C_{DOM} in the clinker were developed. The C_{DOM} content is determined in the following way:

3.1 Reagents

Sulfuric acid:	H_2SO_4 conc. p.a. min. 96%
Solution of potassium dichromate 0,267:	13,0920 g $K_2Cr_2O_7$ are dissolved in ca 200 ml H_2O; then 550 ml H_2SO_4 conc. are slowly and carefully added with continual stirring. The solution is made up to 1 liter with H_2O.
Solution of ferrous ammonium sulfate 0,2 N:	50 ml H_2SO_4 conc. p.a. are carefully added to 600 ml H_2O. Then, 78,400 g of $FeSO_4(NH_4)_2SO_4 \cdot 6H_2O$ (Mohr's salt) are dissolved in the solution, which is then made up to 1 liter with H_2O.
N-phenylanthranilic acid-indicator:	200 mg of N-phenylanthranilic acid are dissolved in 50 ml of a 0.2 % solution of Na_2CO_3, and the solution is made up to 100 ml.

3.2 Preparation of the sample

The clinker is dried at 105°C until its weight is constant. It is then very finely ground in a ball mill and kept in a closed bottle. Depending on the sample, drying takes 24-48 hours, grinding 2-6 hours. All results relate to dried clinker.

3.3 Procedure

A 0,3000 g sample is weighed in a 300 ml round flask with a ground-glass joint. Exactly 30 ml $K_2Cr_2O_7$ solution are added from a buret and well mixed with the sample. The retort is connected to a reflux condenser. The mixture is heated exactly one hour on a boiling water bath. Then the retort is cooled with ice water and the condenser is rinsed with H_2O. Eight drops of indicator are added. The backtitration of the unused $K_2Cr_2O_7$ is carried out with the FeAmS-solution. When the indicator is added, the mixture turns brown-green. During titration the color changes through violet to green. As soon as the violet color appears, another 8 drops of indicator are added. At the end of the titration the violet color changes with one drop of titration solution to bright green.

The green color may appear even when the indicator is first added. In this case the titration must be repeated with a larger quantity of $K_2Cr_2O_7$ or with a smaller sample. In the same way as with the sample, a parallel titration is carried out with a blank.

3.4 Calculation

In soil analysis an average content of 58% C in soils is assumed /9/. Since the corresponding ratios in refuse clinker are not known, the results are expressed as % "C_{DOM}."

One ml 1N $K_2Cr_2O_7 \equiv 3$ mg O_2 which can oxidize 3 mg C to CO_2.

$$\% \, C_{DOM} = \frac{(a-b) \cdot N \cdot 0.003 \cdot 100}{c}$$

or

$$\% \, C_{DOM} = \frac{0.3 \cdot N\,(a-b)}{c}$$

where a = ml FeAmS solution for blank test
b = ml FeAmS solution for backtitration
c = quantity of the sample in g
N = normality of FeAmS solution.

4. Reproducibility of method

The standard of deviation of a single determination can be calculated from a series of double analyses in the following way

$$SD = \sqrt{\frac{\Sigma\Delta^2}{2n}}$$

where Δ = the difference between 2 analyses of the same sample
n = the number of samples in one series.

In order to find out if the method is reproducible, a number of double determinations of C_{DOM} were carried out in different clinkers (Table 7).

TABLE 7.

No.	Sample No, (refuse clinkers)	C as C_{DOM}		Average value	Absolute difference	
		I	II		Δ	Δ^2
1	1	1,12	1,12	1,12		
2	2	3,6	3,6	3,6		
3	722	4,6	4,58	4,59	0,02	0,0004
4	704	3,18	3,10	3,14	0,08	0,0064
5	706	3,70	3,80	3,75	0,1	0,01
6	702	4,35	4,23	4,29	0,12	0,0144
7	703	5,1	5,18	5,14	0,08	0,0064
8	705	5,20	5,32	5,26	0,12	0,0144
9	711	3,48	3,50	3,49	0,02	0,0004
10	707	4,44	4,52	4,48	0,08	0,0064
11	723	3,50	3,56	3,53	0,06	0,0036
12	721	3,12	3,08	3,10	0,04	0,0016
13	746	1,52	1,52	1,52		
14	747	1,90	1,91	1,905	0,01	0,0001
15	745	3,97	3,97			
16	741	4,04	4,02	4,03	0,02	0,0004
17	743	3,92	3,91	3,915	0,01	0,0001
18	722	4,52	4,58	4,55	0,06	0,0036
19	708	3,82	3,82	3,82		
20	710	3,45	3,43	3,44	0,02	0,0004
21	712	2,10	2,07	2,085	0,03	0,0009
				$\Sigma AV = 3{,}56$		$\Sigma\Delta^2 = 0{,}0695$

The standard deviation of a single determination is 0.04 (absolute difference), or 1.12 % (difference in %). The method, therefore, is very well reproducible.

5. Comparison tests

The method was tested with mixtures of different clinkers with pure cellulose or saccharose.

The results thus obtained were compared with the results calculated by adding the C_{DOM} values of the individual components (Table 8).

TABLE 8.

No.	Material	%C_{DOM} found (average value)	%C_{DOM} calculated	% error
1	0,300 g sample 1 + 0,015 g saccharose	2,92	2,98	2,4
2	0,150 g sample 706 + 0,015 g cellulose	7,23	7,23	-
3	0,150 g sample 703 + 0 02345 g saccharose	8,96	9,0	0,44
4	0,150 g sample 711 + 0,015 g saccharose	6,98	7,0	0,28
5	0,150 g sample 707 + 0,01655 g cellulose	8,21	8,21	-
6	0,150 g sample 746 + 0,015 g saccharose	5,16	5,20	0,7
7	0,150 g sample 747 + 0 015 g saccharose	5,6	5,56	0,71
8	0,150 g sample 745 + 0,015 g saccharose	7,45	7,43	0,29

There is agreement between results found and results calculated.

6. Summary

A new method of determining the carbon content in unburnt decomposable organic matter (C_{DOM}) contained in refuse clinker is described.

Decomposable organic matter is decomposed for an hour under strict conditions (wet combustion with $K_2Cr_2O_7$ and H_2SO_4 at 100°C), the unused $K_2Cr_2O_7$ is retitrated with $FeSO_4(NH_4)_2SO_4 \cdot 6H_2O$. The process is very simple and quick. The method is also suitable for quantities of less than 1 % C_{DOM}.

As the comparison tests show, the method yields exact and easily reproducible results.

Bibliography

1. Rollé, G. and B. Orsanic. Informationsblatt der I. A. M., Vol. 21, No. 3. 1964.
2. Schollenberger. Soil Sci., Vol. 24, No. 65. 1927.
3. Rauterberg, E. and F. Kremkus. Z. Pflanzenernähr., Düng., Bodenkunde, Vol. 54, (99), 240. 1951.
4. Springer, U. and J. Klee. Z. Pflanzenernähr., Dung., Bodenkunde Vol. 64, (109), 1954.
5. Kurmies, B. U. Pflanzenernahr., Dung., Bodenkunde Vol. 44, (121), 1949.
6. Simakov, V. N. Pochvovedenie (Pedology) Vol. 36, 1931.
7. Mebius, L. J. Anal. Chim. Acta, Vol. 22, 120, 1960.
8. Jackson. Soil Chemical Analysis, Prentice Mall, Inc., N. J. 1958.
9. Thun, R., R. Hermann and E. Knickemann. "Die Untersuchung von Boden" Methodebuch, (Examination of Soils) Vol. 1, Neumann Verlag, Berlin 1955.

10. Gerretsen, F. C. and W. A. O. Campen. Informationsblatt der I. A. M., Vol. 5, No. 10, 1958.

DYNAMICS OF CHANGES IN THE SIFTINGS FROM MUNICIPAL REFUSE AND SEWAGE SLUDGE IN THE COURSE OF THE YEAR

By Dr. B. Novák, Ing. F. Lobl, Ing. R. Apfelthaler, and Dr. J. Pokorná-Kozová

The siftings of municipal refuse and sewage sludge are the main raw materials for producing industrial compost. Since it is necessary to continue uninterrupted production of industrial compost throughout the year, and because the products should have as uniform a standard as possible, it is important to know the properties of the raw material used. Examination for these is urgent because each dumping of voluminous materials increases the direct expenses for producing the compost as well as the losses of organic matter and sometimes nutrients.

Material and Methods

For these reasons, in the years 1960 and 1961, we systematically examined in Prague the composition of the raw materials. Siftings were obtained in Prague's refuse incineration plant by sieving the refuse on a 20-mm rotary sieve; the sewage sludge was taken from the sedimentation containers of Prague's municipal sewage purification plant. The sludge was either in the raw state (directly after sedimentation) or digested (after fermentation and extraction of combustible gases). The samples, taken regularly in intervals of 2 weeks, were brought immediately to the laboratory and treated.

We sorted the siftings in 3 fractions, as follows: A, larger than 5 mm; B, 2—5 mm, and C, smaller than 2 mm. Other than the mechanical elimination of such typical parts as paper and other organic components, clinker, glass, and metals, all analyses were made only from these three fractions of the siftings. For the chemical, biochemical, and microbiological analyses, the fractions A and B were ground to a size of less than 2 mm.

The siftings were examined for their physical value, chemical composition, microbiological colonization and biochemical activity.

The following physical values were determined in the siftings: compressibility of the heaped sample at a progressive load per cm^2, porosity, and bulk weight.

Before making the analyses, we homogenized the raw sludge and the digested sludge on a quick-running homogenizing machine.

The analyses included the chemical combination, microflora, and biochemical activity.

Among the chemical analyses were determination of the organic matter by combustion; oxidimetrical determination of C, of N according to Kjeldahl, of NH_4^+ according to Conway, of P_2O_5 colorimetrically, and of K_2O and Na_2O flame-photometrically.

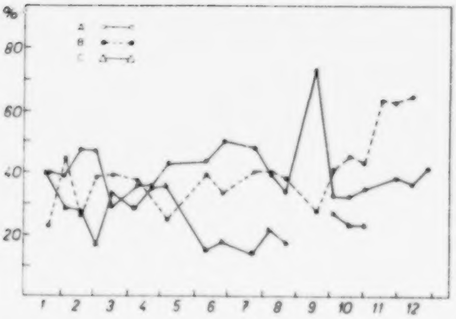


FIGURE 1. Proportions of fractions A, B, C in the siftings in the course of the year.

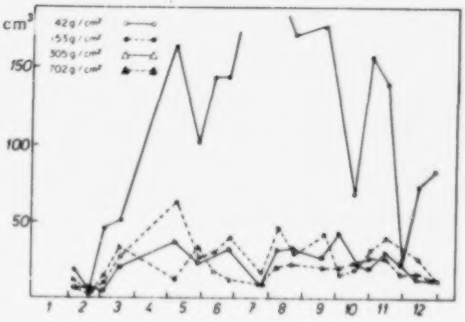


FIGURE 2. Compressibility of fraction A in the course of the year.

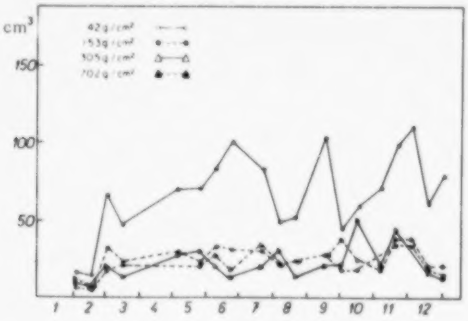


FIGURE 3. Compressibility of fraction B in the course of the year.

The microbiological tests included determination of the number and types of aerobic microbe colonies and turbidity of the anaerobic culture on the following nutrient media: meat peptone agar and meat peptone bouillon, starch agar and starch solution, Thorton agar and Thorton solution, Ashby agar and Ashby solution, Jensen agar and Henneberg agar. On meat peptone agar, determinations were made of the total number of bacteria and the spores of the bacilli. We evaluated bacteria and actinomycetes separately on starch agar and Thorton agar.

We learned the biochemical activity with the aid of respirometry and by determining both cellulose ammonisation and intensity of its decomposition. We measured the respiration from CO_2^- production, namely interferometrically, volumetrically, and by titration; the ammonification was determined by the diffusion method, as changes of $N\text{-}NH_4^+$. These tests were carried out as actual and potential determinations. The intensity of cellulose decomposition was determined on agar dishes (aerobic) and in solutions (anaerobic).

Siftings

Examination of the proportional participation of fractions A, B, and C showed essential differences in the course of the year. Figure 1 shows that fraction A preponderates mostly, fraction B seldom, and fraction C exceptionally.

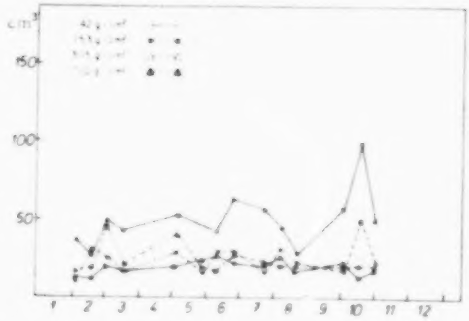


FIGURE 4. Compressibility of fraction C in the course of the year.

The comparatively highest values came from fraction C in the cooler season, which fits the finding that this fraction is formed predominantly of fine ash. The graph of fractions A and B has approximately two peaks; fraction A is especially interesting. The maximum in the winter half-year is caused by the large proportion of clinker, the maximum in summer, however, is due to the large quantity of larger pieces of organic waste (vegetable waste, paper). It should be noted that in the summer period, the preponderant part of organic matter from the dustbins does not get into the siftings at all because the single pieces are mostly of larger diameter than 20 mm.

Further analyses prove that in the course of the year changes occur not only in the proportion of the fractions in the siftings, but also in their character. Fraction A is the most compressible, the siftings of the summer half-year being more compressible than those of the winter half-year. By increasing pressures, a smaller reduction of the volume is attained. Obviously, the compressibility is connected with the porosity of the siftings; it is not directly proportional, however. We observed that, especially in the winter half-year, it is small, with a relatively high porosity (Table 1).

TABLE 1. Porosity and compressibility of the fractions A, B, C in the summer and winter half-years

Half-year	Fraction	Porosity %	Compressibility %
Summer	A	64,-	40,1
	B	53,-	30,-
	C	54,1	28,6
Winter	A	61,-	6,5
	B	60,-	10,-
	C	58,6	19,1

In the summer half-year, however, the ratio of maximum compressibility to porosity is relatively small. This results in the fact that in the winter half-year a high porosity can be attained, also at higher pressures, especially in the rougher fractions; while in the summer half-year the porosity quickly decreases with increasing load.

The bulk weight of the siftings is not only a function of the porosity, but is, at the same time, a function of the correlative ratio of the organic and mineral matter, which changes markedly. Mostly, fraction A has a smaller bulk weight than fraction B, and fraction C usually has the highest.

TABLE 2. Proportions of clinker and ashes, glass and organic matter in the siftings in the course of the year

Week	Clinker and ashes %	Glass %	Organic matter %
3	92,34	0,41	7,16
7	91,58	3,98	4,44
9	89,24	4,94	5,25
11	86,26	0,58	13,05
14	92,53	0,93	6,54
16	90,15	0,62	9,22
18	84,64	1,11	14,25
21	84,12	2,76	12,30
23	75,19	1,60	23,20
25	65,80	1,05	33,15
29	72,97	3,11	23,92
31	48,34	0,55	51,11
33	74,51	6,13	19,36
39	80,37	3,89	15,74
43	84,53	1,96	13,51
47	84,17	1,64	14,19
49	94,18	1,11	4,69
51	93,40	-	6,60

At the mechanical sorting of the main parts we noted a negative correlation between the contents of organic matter and cinder. The greatest content of organic matter was observed in the summer half-year.

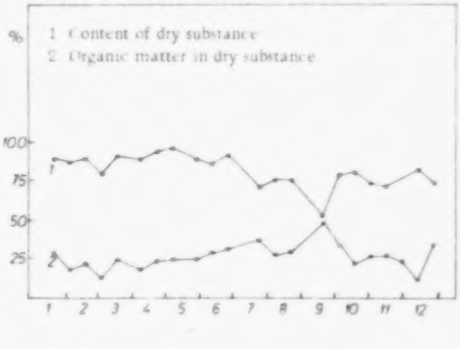


FIGURE 5. Content of dry substance (%) and content of organic matter in the dry substance of fraction A.

These results were confirmed by chemical analyses, especially with the aid of the loss-on-ignition method, while the oxidimetric determination of carbon shows more fluctuating results (Figures 5 and 6).

The nitrogen analyses are very instructive. They proved that the organic matter in the winter half-year is formed by material poor in nitrogen, while an essential part of the material in the summer half-year is rich in nitrogen. The C:N ratio is very unfavorable in the winter months' siftings (too much spread out — 100:1 and more), while in the summer months it comes near to the value 10. These differences are most distinct in fraction A, and less distinct in fraction C, which was expected.

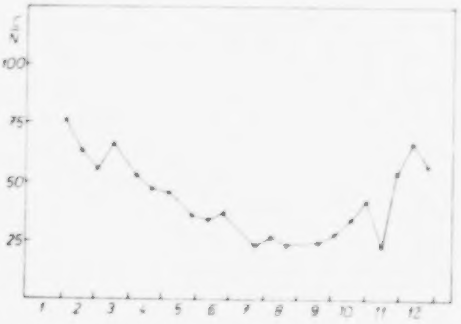


FIGURE 6. C:N ratio in fraction A

Relatively reliable characteristics of the variability of the basic materials can be obtained by analysis of the mineral nutrients, for these are relatively constant for a certain time, while the content and form of carbon and nitrogen may change very quickly. A survey of the chemical composition of the siftings, in reference to their P, K, Ca, and Na content, is given in Table 3.

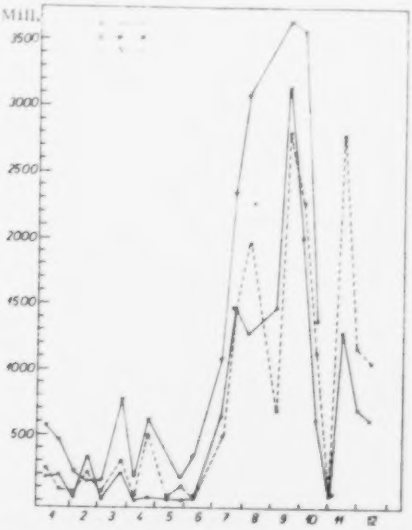


FIGURE 7. Germs on peptone agar from meat water fractions A, B, C.

TABLE 3 Changes of P, K, Ca and Na in different fractions of the siftings in the first half of the year

Week	Fraction	P_2O_5 mg %	CaO %	K_2O %	Na_2O %
3	A	121,-	2,55	0,679	0,430
	B	70,7	3,93	0,729	0,294
	C	104,-	2,88	0,824	0,450
5	A	82,7	2,58	0,431	0,344
	B	70,8	3,19	0,495	0,421
	C	52,-	0,36	0,622	0,554
7	A	56,1	1,39	0,567	0,294
	B	-	-	-	-
	C	43,7	4,52	0,547	0,444
9	A	63,3	0,43	0,506	0,417
	B	63,7	1,66	0,514	0,269
	C	60,3	2,92	0,603	0,392
11	A	63,3	0,40	0,529	0,318
	B	70,-	0,40	0,659	0,385
	C	61,90	3,40	0,712	0,501
14	A	-	-	-	-
	B	36,-	3,44	0,437	0,400
	C	42,5	4,77	0,473	0,441
16	A	10,6	2,65	0,618	0,395
	B	8,8	2,69	0,541	0,369
	C	8,6	4,34	0,640	0,469
18	A	11,5	2,76	0,627	0,431
	B	-	-	-	-
	C	12,3	3,56	0,767	0,494
21	A	39,9	3,-	0,696	0,054
	B	-	-	-	-
	C	-	-	-	-
23	A	14,5	3,15	1,160	0,619
	B	-	-	-	-
	C	114,-	3,51	0,686	0,445
25	A	16,4	2,46	0,630	0,438
	B	5,25	2,92	0,601	0,418
	C	6,1	3,09	0,890	0,470
29	A	-	-	-	-
	B	-	3,40	0,670	0,290
	C	-	3,25	0,720	0,710

Changes in the microflora are connected with changes of the physical, and especially the chemical, properties of the siftings. In the summer months, the siftings contain many times over the number of microbes they contain in winter (Figures 7 and 8). It is remarkable that the larger quantity of microbes is found in fraction C, which generally contains very little organic matter. It is obvious therefore, that not only the organic matter has an influence on the increase of the microflora, but also the conditions of the different parts, particularly their total surface area. Hence, the number of microbes in relation to the relative quantity of carbon is highest in fraction C. Its fluctuations are greater than in fractions A and B.

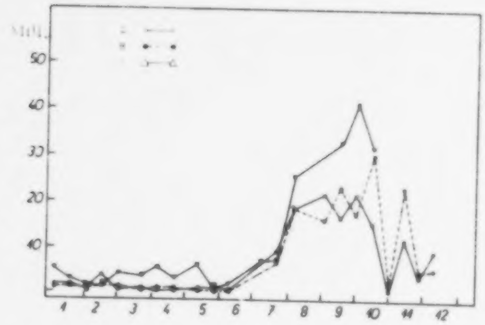


FIGURE 8. Fungi in fractions A, B, C (on Jensen-agar).

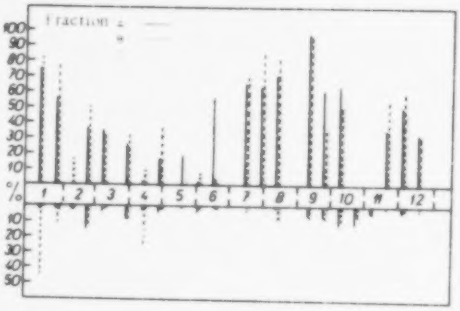


FIGURE 9. Intensity of decomposition of cellulose in aerobic (above) and anaerobic (below) incubation conditions in siftings.

The ability of microflora to decompose cellulose is interesting (Figure 9). While it is highest in the summer period, in winter it is sufficiently high also, but in spring and in autumn it varies strongly. This agrees with the general composition of organic waste observed in the siftings. In winter, we find paper mainly; in spring and summer, larger quantities of waste from young vegetables appear, viz. matter with a small content of cellulose; in late summer, the vegetable waste is richer in supporting tissues, thus richer in cellulose; in autumn, ash contains a greater part of spoiled fruit and its residue, as this is largely composed of simple sugars and organic acids.

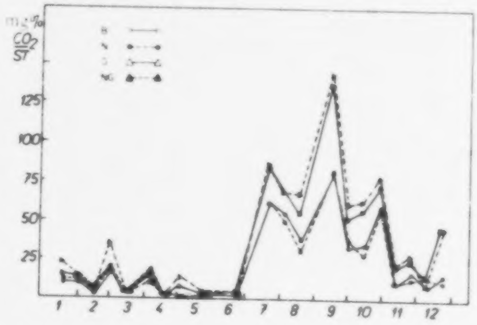


FIGURE 10. Actual and potential respiration speed of fraction A.

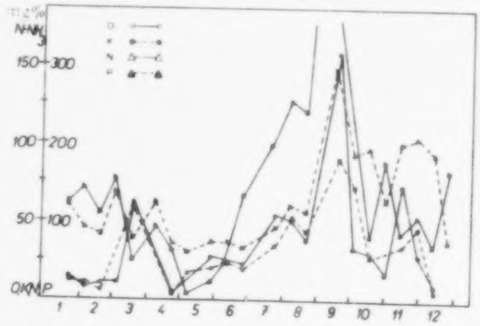


FIGURE 11. Strength of ammonification of fraction A.

In all fractions of the siftings, the aerobic microflora is more strongly represented than the anaerobic. The microflora is often numerically great, but according to species and type, relatively simple. Actinomycetes appear to a smaller extent.

Biochemical tests give a comprehensive illustration of the microflora's activity and the complex of conditions in which microflora is active. Figures 10 and 11 show that respiration and ammonification are highest in the summer months and vary in the different fractions. These differences are greatest in fraction A, and least in fraction C.

On evaluating the quality of the organic matter and the formation of humus, based on the results of the biochemical tests, and especially on the relative strength of the respiration, we find no essential differences in the course of the year.

Sewage sludge

Not only raw sewage sludge, but also digested sewage sludge is a much more homogeneous material than siftings. Although there are variations in chemical composition and in colonizing with microbes here also, we can speak about a certain average composition during the whole year, or during certain periods. Based on these observations, we may conclude that in the sewage purification plants of the type mentioned sludge of the following composition is obtained:

	Raw sludge	Digested sludge
Dry matter in %	8 ± 1,5	6 ± 1
Carbon in %	2,80	1,20
Total nitrogen in %	0,20	0,20
N-NH_4^+ in mg %	25	180
P_2O_5 in mg %	14	45
K_2O in mg %	60	65
CaO in mg %	70	200
Na_2O in mg%	50	50

Raw sludge has more dry substance and a higher quantity of carbon, absolutely and in the dry substance, than has digested sludge. Both contain an approximately equal amount of nitrogen. While raw sludge contains the maximum quantity of dry substance in the warmest months, digested sludge in the same period shows a slight decrease in this value. The C:N ratio in raw sludge is doubtless wider, but more constant than in digested sludge. This arises from a greater regularity of the general quality of organic substances in raw sludge, compared to that in digested sludge. The dynamic agreement of the mineral nutrients in both forms of sludge, especially of P_2O_5 with few changes in sorption and desorption, indicates that the differences in quality of organic matter in raw sludge and in digested sludge are caused by decomposition, and in no way by different quality in the basic substrate.

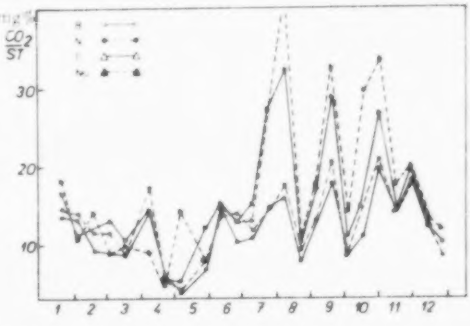


FIGURE 12. Respiration speed of raw sludge

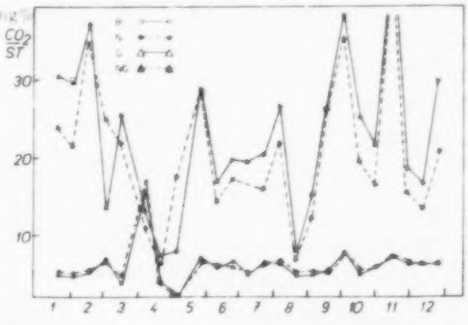


FIGURE 13. Respiration speed of digested sludge.

Figures 12 to 15 show the respiration and the changes of N-NH$_4^+$ in raw and digested sludge in the course of the year. A connection between the quantity and the quality of organic matter and the findings of these tests is clearly perceived.

Basic utilization of organic matter by microflora is much lower in digested sludge than in raw sludge.

Raw sludge appearently has a certain deficiency of physiologically utilizable nitrogen, while a surplus of nitrogen exists in digested sludge. The capability of microflora to synthetize from raw sludge is higher than from digested sludge during the greatest part of the year. The organic matter of raw sludge is microbiologically more accessible than that of digested sludge.

The real microflora of raw and especially of digested sludge is rather homogeneous. Although microflora contains a high percentage of anaerobic microbes, a large part is aerobic.

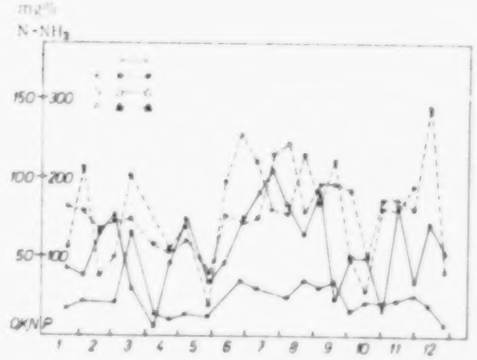


FIGURE 14. Ammonification strength of raw sludge

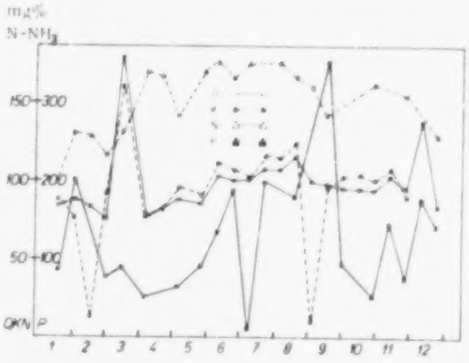


FIGURE 15. Ammonification strength of digested sludge

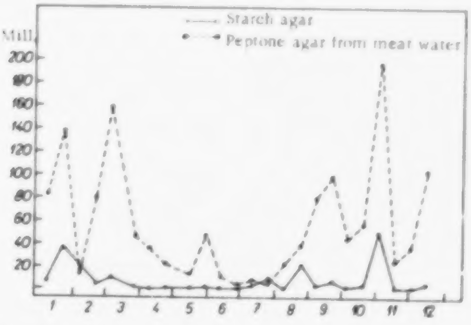


FIGURE 16. Number of germs in raw sludge.

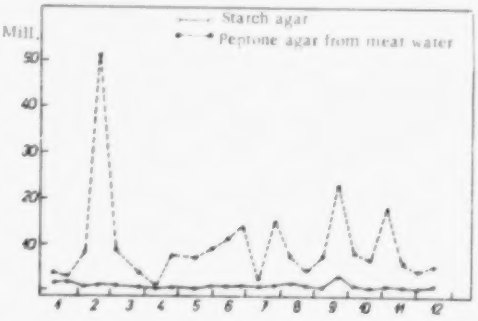


FIGURE 17. Number of germs in digested sludge.

As Figures 16 and 17 show, microflora is considerably more numerous in raw sludge than in digested sludge. In both cases, microbes utilizing nitrogenous organic matter outnumber the microbes using glycide and mineral nitrogen. These findings agree with the chemical analyses. More yeastlike organisms than thread fungi are found in the nonbacterial forms of the microorganisms, which are not numerous in raw sludge, and appear in digested sludge in even smaller numbers. Actinomycetes were not found in the sludge.

The intensity of the cellulose decomposition is, in certain cases, higher in the digested sludge than in the raw sludge (Figure 18).

In general, this capacity of the microflora is rather variable; sometimes a higher activity is found in aerobic conditions and sometimes in anaerobic conditions.

Sewage Sludge and Siftings as Raw Material for Compost

Our observations confirmed in general the fact that the quality of winter and summer siftings differed from the point of view of composting. We tried to show several reasons for this difference. In general, it can be stated that there are differences in the mechanical composition, the physical values, and the chemical composition, as well as in colonization by microorganisms and in microflora activity.

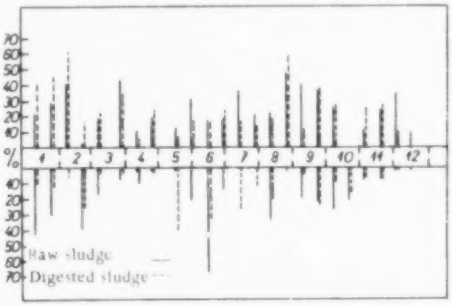


FIGURE 18. Intensity of decomposition of cellulose in aerobic (above) and anaerobic (below) incubation conditions in sewage sludge

The different content of organic residue and ashes in the siftings is, obviously, the basic reason for these differences. The other materials are either disposed of by sieving or do not form an essential part of the siftings, so that they apparently have no marked effect on the general quality. The organic matter seems to be important, not only in its quantity, but also in its quality and degree of dispersion.

When judging siftings as raw material for composts, totality of properties has to be appraised. We believe that the mechanical-physical values enable the inclusion of the siftings as a regular component of compost production. In the composting of municipal refuse, they are the main source of the solid part of compost, and they form the framework for the other raw materials. It is desirable, therefore, that when piled up loosely they have as high a porosity as possible, with compressibility as low as possible. Siftings of the summer months meet the first condition largely, the winter siftings the second condition.

It is evident therefore, that the technological processing of summer and winter siftings should be different because of their physical properties. For instance, maintenance of the necessary porosity of compost would require that the compost pile be lower when summer siftings are used and higher when winter siftings are used. This need fully agrees with the other conditions for composting; taking into consideration the heat regime (development of heat by decomposition and heat radiation into the surroundings) and the intensity of the microflora's use of

O_2 and the subsequent changes in the oxidation-reduction system, it is usually expendient to make windrows in winter larger than in summer.

Quick and economical fermentation of compost requires the addition of further materials to siftings. Quality demands for the additional materials needed for decomposing raw summer siftings are lower than for those needed for winter siftings. Winter siftings composted in winter require inclusion of raw material rich in organic matter and nitrogen, a considerable portion of the organic matter should be utilizable by the microflora.

Chemical composition of the siftings shows that summer siftings are most suitable for decomposition because they contain a maximum amount of organic matter and nitrogen. Because winter siftings contain less organic matter, they are less suitable for use by the microflora, and deficiency of nitrogen creates further difficulty. The microflora is most numerous in summer siftings, which, considering their physical properties and their chemical composition especially, is generally expected. Nevertheless, it is surprising that the microflora appears in greatest strength on the fine particles of the siftings, although these contain a smaller quantity of organic matter. This fact obviously is connected with the size of the whole surface of the particles and could lead to the conclusion that microbial efficiency could be increased by grinding the siftings particles, thereby accelerating fermentation of the compost. This point of view, however, contradicts the demands on the physical properties of the compost, so that other ways must be found for further activating the microflora.

In general, the microflora of the siftings is very uniform, the microbes mostly being completely different from typical soil microbes and, contrary to all expectations, actinomycetes appear only in small quantities. This qualitative, microbiological composition is in only an imperceptible measure, better in the summer months than in winter. It can be concluded therefore, that from the point of view of modern demands on the intensity and productivity of humification, the microflora of siftings is not suitable for quick and satisfactory fermentation of compost.

Sludge from sewage purification, if it is not compacted, contains water to a great extent. Raw sludge has, on the average, a greater part of dry substance and a greater percentage of organic matter in the dry substance than has digested sludge. Both types of sludge as a source of nitrogen are equal in value and rather productive.

Accessibility of organic matter in digested sludge is smaller than in raw sludge. The number of microflora of both types of sludge, and especially of digested sludge, is small and, in regard to composition of the species, not much variegated. It can be assumed that, especially in the case of digested sludge, it is an indifferent or negative factor in composting.

Because of the great surplus of water in sewage sludge, and owing to unsuitable consistency of partly drained sludge, these can be efficiently composted only together with other material. For this purpose, siftings, especially of the summer months, are very well suited. Because the absorption capacity of siftings, especially winter siftings, is small (the maximum percentage of liquid sludge which can be added to composts of siftings and sewage sludge is 20—30%, exceptionally 40%), it can not be supposed that mixing of siftings and liquid sewage sludge during the winter will secure the necessary quantity of organic matter for good fermentation of compost. In such cases, it will be necessary, and in other cases it will be at least useful to add further raw material to the mixture. Special consideration should be given to the fact that neither siftings, sewage sludge, nor a number of other wastes are a reliable source for suitable, sufficiently active microflora. Therefore, at least one raw material which could be the source of these microbes for all the compost, viz., the vaccine, has to be included in the mixture.

DETERMINATION OF SALES EXPECTATIONS FOR REFUSE COMPOST AS A BASIS FOR PRELIMINARY INVESTIGATION

By Dipl. Landw. A. v. Hirschheydt, EAWAG, Zurich

1. Outline of the Problem

If, in the course of overall planning, it will be decided that composting will be considered a partial solution of the waste disposal of a district, very soon the question will arise what to do with the compost. There will be 3 possibilities:

a) dumping
b) marketing, i.e., rate-free distribution in some areas
   ba) without refunding transport and production costs to the producer
   bb) with compensation for these services
c) sale at a higher or lower price ex works.

In this paper only c) will be dealt with, because in practice only this case requires a more thorough investigation. There is a widespread belief, often publicly voiced and mostly insufficiently or not at all substantiated, that Western Europe is unable to produce enough compost to cover the enormous demand for this valuable product. This opinion is the reason for the considerations, examinations and results presented in this paper.

It is, of course, not possible for the author to form an opinion concerning the situation in the whole of Europe. As far as can be judged so far (this applies in the first place to Switzerland and the German Federal Republic), the consumers apparently do not always attribute to the compost the value it deserves. If the actual readiness to purchase is a measure for the degree to which a product is desired, a certain discrepancy between the opinions of different experts in this respect also is undeniable.

It appears very important therefore to work out a method that will make it possible to evaluate the probable marketing potential according to as objective criteria as possible. Obviously, this is at first an experiment which is bound to have a number of shortcomings. If, however, the results are interpreted with the necessary caution, it is possible to obtain basic values which can be used in practice and which allow additional measures in the field of refuse disposal in this connection to be based on well-founded information.

The method used and the results obtained by it shall be discussed here.

2. Method

At the beginning of 1965 the author was charged with the task of examining the possibilities of and limits for the use of refuse compost in Switzerland. Few sources were at the author's disposal. It was therefore necessary to find to a large extent a new approach.

On the one hand, the branches of the economy to be included in the examination had to be specified; on the other hand, the characteristic values had to be determined and defined, which would make it possible to calculate the actual requirement for organic fertilizers and also the probable marketing potential according to c).

2.1 Consumers

Practically all branches that are dependent on additional purchase of organic fertilizers are potential users of refuse compost (henceforth designated RC). Expressed in a negative way, this means the elimination of all economic forms to which this demand does not apply. They include the large number of agricultural enterprises predominantly based on their own farmyard manure. Therefore the following forms of soil utilization can be taken into consideration:

Public parks
domestic gardens and allotments
orchards
tree nurseries including forest
vegetable gardening
viticulture
floriculture and ornamental plants.

Objections to this selection could be raised on the grounds that agriculture has some scope at least, and that the broad field of the garden and landscape architecture is not taken into consideration. Nevertheless, we must neither ignore the enormous decline in the purchase of compost by Dutch agriculture /1/, nor the fact that, so far, neither in Switzerland nor in Germany could appreciable quantities of compost be sold to this branch of the economy. Landscape and garden architecture are included in either public parks or in domestic gardens and allotments.

2.2 Determination of Areas

The determination of the areas caused considerable difficulties because up-to-date statistical material was not available for all areas; for public parks, gardens and allotments there is none at all. Hence the two alternatives, either to partially or completely disregard the last-mentioned consumers, or to make do with estimates based on comparative figures. This was done by using the data from comparable areas of the German Federal Republic /2/.

In practice the area of these forms of utilization in individual cantons or districts was determined according to three types of region. For the other economic branches sources were available /3, 4, 5, 6, 7, 8/, some of which could be used directly, some had to be converted.

In general, the total area is therefore relatively uncertain. However, the final result is likely to agree with the facts to such an extent that the results can be used and conclusions can be drawn.

2.3 Requirements

The next step is the determination of the objective or potential demand (henceforth designated PD) for compost. This means the quantity of RC required per area unit and year to keep the humus level constant at stipulated height, i.e., to compensate for the annual degradation of humus. Using average degradation values according to Kortleven /9/ and average humus contents, the following table is obtained:

Economic form	Area, 1,000 ha	PD, t/ha per year	PD, 1,000 t/year
Public parks	4,4	16	70,9
Gardens and allotments	28,4	15	424,8
Orchards	3,3	15	49,9
Vegetable gardening	1,5	29	35,9
Tree nurseries incl. forest	0,5	140*	73,0
Viticulture	10,8	16	174,7
Floriculture and ornamental plants	1,0	29	25,4
Total for Switzerland and Principality of Liechtenstein	49,9	-	854,6

* Theoretical demand according to Research Institute Birmensdorf.

For the determination of the marketing potential, from the calculated PD at least the price of comparable fertilizer obtainable at a more favorable price than RC has to be subtracted. Besides this, a number of additonal factors has to be taken into consideration, e.g. the fact that orchards in Switzerland are often situated on grass cover, that gardens and allotments in the humus sector are frequently totally neglected, etc.

Since the data for such an abbreviated operation cannot practically be worked out, Dutch refuse disposal was studied to determine settled demand (henceforth designated SD) /10/. Reduction factors, expressed in % of PD, can be derived from this report. Only the calculations for the tree nurseries were based on the experience of the Research Institute in Birmensdorf. These data yielded the following SD for Switzerland and the Principality of Liechtenstein:

Economic form	1,000 t/year
Public parks	8,2
Gardens and allotments	47,5
Orchards	6,1
Vegetable gardening	4,4
Tree nurseries incl. forest	14,7
Viticulture	21,1
Floriculture and ornamental plants	3,2
Total	105,2

3. Practical Application

A research method as described above serves its purpose only if it can be rationally applied and if it permits reasonable conclusions. In the present context this postulate means that an answer can be given to the question if and to what extent a newly erected composting plant may count on sales or, expressed differently, if the predictable sales situation for compost will justify the composting of refuse as a measure of waste disposal in a certain area.

In order to give this answer, it is necessary, besides knowing the demand, to know the already existing supply. On the example of Switzerland it is explained below how the method is applied in practice and how it can lead to conclusions.

3.1 Demand and Supply Attained

In October 1965, 11 composting plants in Switzerland were in operation, and another 3 plants were under construction. The following table shows the maximum quantities of compost that can be expected from these plants now (or initially).

Site	Output of compost in 1,000 t/year*	
	now (initially)	maximum
Kusnacht	2,6	2,6
Ruschlikon	1,2	1,2 **
La Chaux-de-Fonds	4,8	6,3
Chur	3,6	3,6
Uzwil	2,4	2,4
Turgi	6,0	8,0
Villette	3,6	3,6
Buchs/SG	5,4	5,4
Au/SG	3,6	3,6
Hinwil	12,0	12,0
Olten	7,2	7,2
Biel †	14,4	18,0
Horgen †	9,6	10,8
Pfannenstiel †	9,6	12,0
Total	86,0	96,7

* Depending on capacity and local factors

** Will be omitted in future and added to Horgen

† Plant under construction

Considering that refuse and compost are not weighed in all plants, it was assumed that the annual quantity of RC per inhabitant included in the scheme is 120 kg.

This indicates that Switzerland is only about 10,000 tons/year short of its SD.

The survey of sites shows that the composting plants are conspicuously concentrated in the north, especially in northeast Switzerland, whereas the south and the southwest, except Villette, are free (cf. map). If we want to form an opinion about present and future supply and demand, we have to fix a marketing area for the composting plants and draw conclusions from the consumption capacity in relation to supply.

From experience we know that compost in competition with other organic fertilizers cannot be transported over excessive distances. Even at a distance of 30 km transport costs alone are higher than the basic price in the case of relatively expensive RC, thus considerably affecting competitiveness. However, a distance of 30 km is still a matter for discussion, and as the crow flies it forms the basis for the following considerations. The result is shown on the map. It is already obvious how the sales areas of the plants overlap. In this case, the three planned plants Grenchen, Fullinsdorf and Schaffhausen are included.

But even if they are disregarded a simple calculation shows that the SD of the plants mentioned in the table is, according to their areas, as follows:

Zurich	100%	Bern	6.5%
Luzern	4.5%	Schwyz	100%
Zug	100%	Freiburg	11 %
Solothurn	100%	Basel-Land	44 %

Schaffhausen	6 %	Appenzell	100%
St. Gallen	100%	Graubünden	72 %
Aargau	100%	Thurgau	100%
Neuenburg	100%	Genf	100%

Within the sales area as defined above, SD amounts to 57,000 tons/year, i.e., 53% of the Swiss SD, while the production of at least 86,000 tons/year is in a position to supply about 78% of the Swiss SD. Expressed differently: The minimum output of RC of the defined area is approximately 150% of the corresponding SD; if maximum output is considered, the figure is about 170%.

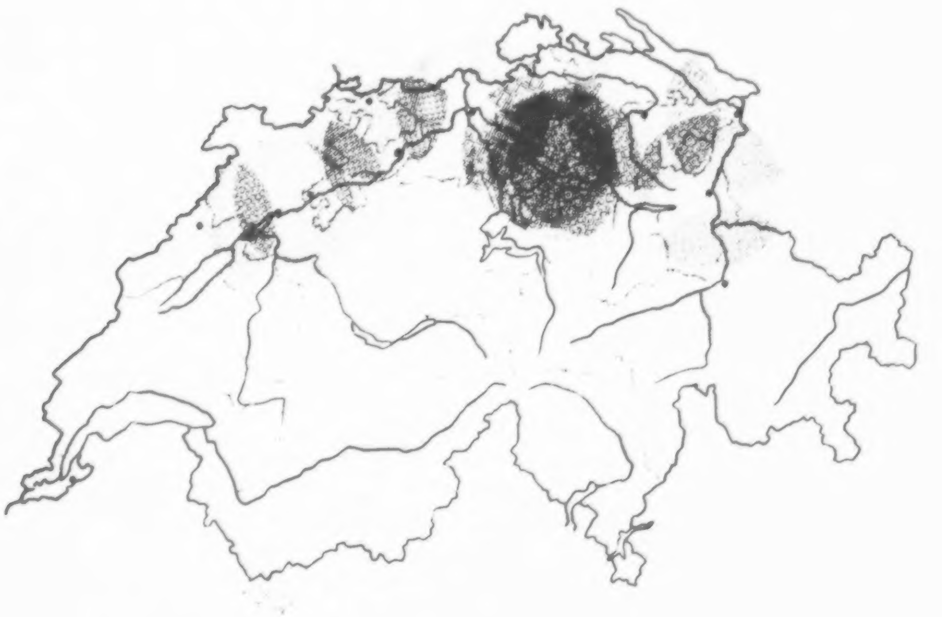
3.2 Conclusions

Which general and special conclusions can be drawn from this? In the first place the following:

Though the method used is not foolproof, it provides orientation figures which, cautiously interpreted, can serve as a working basis.

Whereas exaggerated optimism with regard to the marketing potentialities of compost is out of place, especially if this optimism is founded more on idealism and enthusiasm than on solid expert knowledge, it is found on the other hand that the opinion, just as frequently advanced, that nobody wants RC and that it therefore cannot be sold, is equally unwarranted.

Inside Switzerland overproduction in the north and an unsatisfied calculable demand in the south confront each other. Within the framework of refuse disposal, no composting plants should therefore be erected outside the cantons of Waadt, Wallis and Tessin if an ex-works price of the RC is envisaged. No other possibilities were under discussion.



Bibliography

1. Teensma, B. Veranderungen in der Anwendung von Mullkompost in den Niederlanden seit 1959 (Changes in the Use of Refuse Compost in the Netherlands since 1959). — IAM-Informationsblatt No. 23, p. 13 ff.
2. Statistisches Landesamt Nordrhein-Westfalen. Beitrage zur Statistik des Landes Nordrhein-Westfalen 1960 (Statistics of Nordrhein-Westfalen). — Die Landwirtschaft in Nordrhein-Westfalen, Düsseldorf, 1961.
3. Eidg. Statistisches Amt. Arbeitskrafte in der Landwirtschaft 1960—1961—1962. Traktoren, Melkmaschinen, Bodenbenutzung (Manpower in Agriculture in 1960—1961—1962. Tractors, Milking Machines, Soil Utilization). — Statistische Quellenwerke der Schweiz, Bern, Issue 344, 1963.
4. Eidg. Statistisches Amt. Wohnbevolkerung der Gemeinden 1960 (Inhabitants of Municipalities 1960).
5. Eidg. Statistisches Amt. Stat. Quellenwerke der Schweiz. Gartenbau, Fischerei- und private Forstbetriebe in der Schweiz 1955 (Statistical Sources of Switzerland. Horticulture, Fishery and Private Forestry Enterprises in Switzerland 1955). — Q 310.
6. Eidg. Statistisches Amt. Stat. Jahrbuch der Schweiz 1964 (Statistical Yearbook of Switzerland 1964). — Birkhauser-Verlag, Basel, 1965.
7. Amt fur Statistik des Furstentums Liechtenstein. Anbaustatistik 1960. Anbauerhebung vom 21. Juni 1960 (Cultivation Statistics. Cultivation Survey of 21 June, 1960). Vaduz.
8. Surber, Dr. E. Mitteilungen vom 27.10 and 9.11.1965 (Communications of 27 October and 9 November 1965).
9. Kortleven, J. Kwantitatieve Aspecten van Humusopbouw en Humusafbraak. Vers. Landbouwk. Onderz. Nr. 69. 1-Wageningen.
10. Stichting Compost. De behoefte aan stadsvuilcompost in nederland. Wageningen.

INAUGURATION OF A COMPOSTING PLANT IN MADRID (SPAIN)

By Dr. J. de la Rubia

In the presence of members of the government, the Mayor and members of the city council, and representatives of the Ministries of Agriculture and Health, a composting plant was inaugurated in Madrid. The plant was consecrated by the Archbishop of the diocese.

This modern plant was erected in the record time of 9 months. Its capacity is 200 t/day. The 200 tons of sorted comminuted waste are mixed with sewage sludge. The sewage sludge has a moisture content of 70% and a dry weight of 40-60 tons.

The plant is situated on the bank of the river Jarame, about 15 km from the town, and it covers 25,000 m^2, the dumping area included.

ABORGAM SA concluded with the city an agreement for the operation of the composting plant which will work according to the SCEBA-EDIFESA system with accelerated aerobic decomposition.

The refuse is unloaded in the DORR-OLIVER reception bunker. After sorting, which is carried out in part manually, but mainly mechanically and magnetically, it is ground in two DORR-OLIVER refuse rasps and a GONDARD mill.

These three machines work in parallel, but in such a way that the residues from the refuse rasps can be passed through the GONDARD mill as well. The use of two different types compensates the advantages and disadvantages of both systems.

After comminution the material is sorted ballistically.

Freed of foreign matter, the material is then transported for decomposition to a building covering 2350 m². This building has 10 corridors, each 3.5 m wide, 40 m long and 2.5 m high.

A distributor unloads the ground refuse onto a centrifuge which hurls the material outward until about one-third of the corridor is filled. During this process the powdered refuse is sprinkled with a biochemical liquid. This liquid contains enzymes, growth substances and activating agents, and accelerates the decomposition and increases the moisture content of the material to 50%.

A special machine, circulating in the corridors, collects the decomposing refuse powder in the first third of each corridor, transports it to the second third, and finally from the second to the third third of the corridor. There the stabilized compost is thrown on a belt conveyor which takes it to the storage dump.

This process yields a spongy compost. Thorough aeration of the material ensures a completely aerobic digestion. In order to achieve maximum aerobic conditions, the entire corridor floors are filled with pressure nozzles spaced 1 m apart. Various air meters control and check the aeration.

In order to obtain optimum conditions for decomposition, temperatures, moisture, pH-value, etc. are continuously checked. The resulting compost is of excellent quality and completely free of pathogens.

Sewage sludge will be added to the refuse as soon as the equipment of the purification plant is completed. In order to obtain good mixing, the sludge will be added directly before the refuse powder is hurled into the corridors.

In addition to the equipment described, there are various auxiliary installations such as the laboratory in which the biochemical liquid for sprinkling the refuse is prepared. The plant has an installation in which paper bales, rags, etc. are disinfected by a gas mixture, probably used for the first time in a composting plant.

The cost of the composting plant was about 45 million pesetas. The staff consists of one foreman, three skilled workers, twenty-three auxiliary laborers and two watchmen.

With this plant the city of Madrid will use from now on a rationaly method of disposal and utilization of its refuse which amounts to 1400 t/day. Thus the city follows the example set some years ago by the towns of Pamplona and Saragossa. The compost is a valuable organic fertilizer for Spanish agriculture.

LITERATURE RECEIVED BY THE SECRETARIAT

Arditti,E. Compost from Town Wastes (State of Israel, Ministry of Agriculture, Organic Manures Branch, Tel Aviv). 1965.

Backmeyer,D.P. Liquid Sludge Disposal at Miami, Florida. — Compost Science, Summer, Vol.6, No.2. 1965.

Bayerisches Staatsministerium des Innern. Technische und organisatorische Moglichkeiten zur Mulbeseitigung (Technical and Organizational Possibilities of Refuse Disposal). — Der Stadtetag, Issue 12. 1965.

Behrens,G. Aus der Praxis der Unterhaltung und Ueberwachung von offentlichen grosstadtischen Mullabladeplatzen (Experience in Operation and Supervision of Public Refuse Dumps in Large Towns). — Stadtehygiene, Issue 10. 1965.

Berger, O., and A. v. Warren. The Rotoplug Sludge Concentrator: Developments in Design and Operation, 1959—1965. Paper, meeting of the Metropolitan and Southern Branch, 6th October 1965, Institute of Sewage Purification, Edwards The Printers Ltd., Coventry. 1965

Bonneau, M., Ph. Duchaufour, and F. Mangenot. Etude de l'humification de composts de sciure. Extrait des annales de l'institut Pasteur, Masson et Cie., Vol. 107, No. 3, Paris. 1964.

Bopp, R. Betrachtungen zur Mullverbrennung (Observations Concerning Refuse Incineration). — Aufbereitungs-Technik, 6th year of publication, Wiesbaden. Issue 5. 1965.

Bopp, R. Kehrichtverbrennung — Ist die Schweiz fuhrend im Bau von Mullverbrennungsanlagen? (Refuse Incineration — Does Switzerland Lead in the Construction of Refuse Incineration Plants?). — Technische Rundschau, Verl. Hallwag, Bern. No. 53 of 24. 12. 1965.

Braun, R. Die wesentlichen Probleme der gemeinsamen Kompostierung von Klarschlamm und Mull (Essential Problems of the Combined Composting of Sewage Sludge and Refuse). — Kommunalwirtschaft, Issue 9. 1965.

Braun, R. Möglichkeiten der biologischen Behandlung von festen Abfallstoffen (Possibilities of Biological Treatment of Solid Waste). — Schweiz. Zeitschr. f. Hydrologie, Birkhauser Basel, Vol. 26, Fasc. 2. 1965.

Braun, R. Der heutige Stand der Klarschlammbeseitigung. (The Present Situation in Sewage Sludge Disposal). — Verbands-Bericht No. 87/1 des Verb. Abwasserfachleute. Schweiz. 1965.

Bruhn, M. Erfahrungen mit der Gluckstädter Mullverbrennungsanlage (Experience with the Refuse Incineration Plant in Gluckstadt). — Kommunalwirtschaft, Issue 10. 1965.

Bucksteeg, W. Aktuelle Probleme des Schlamm-Anfalls und der Schlammbeseitigung (Topical Problems of Sludge Supply and Sludge Disposal). — Wasser und Abwasser, Vol. 1963 (Schwebestoffe und Schlamme in Gewässern und Kläranlagen), Verl. Winkler and Co., Wien. 1963.

Busse, O. Die Veraschung, eine wesentliche Verfahrensstufe der wirtschaftlichen Klarschlammbeseitigung (Incineration, an Essential Stage of Economical Sewage Sludge Disposal). — Wasser und Abwasser, Vol. 1963 (Schwebestoffe und Schlämme in Gewässern und Kläranlagen), Verl. Winkler and Co., Wien 1963.

Caruel, R. Les problèmes posés pour la collecte des ordures ménagères par suite de leur évolutions. AGHTM-Congrès de Luxembourg, 14 septembre 1965. — Techniques et Sciences Municipales, 61ème année, No. 1. 1966.

Chrometzka, P. Die Verwendbarkeit des Mullkompostes im Hopfenbau (The Utilizability of Refuse Compost in Hop Cultivation). — Hopfen-Rundschau, No. 11, 1. 6. 1965.

Doose, U. Rechtliche Ueberlegungen zur Beseitigung von Industrieabfallen (Legal Considerations Concerning the Disposal of Industrial Waste). — Der Stadtetag, Issue 10. 1965.

Dorfmann, R. Les problèmes posés par l'évolution de la nature des ordures ménagères pour leur collecte et leur traitement. Rapport général, A. G. H. T. M. — Congrès de Luxembourg, 14 septembre 1965. — Techniques et Sciences Municipales, 61ème année, No. 1. 1966.

Duhme, W. Sperrgutbeseitigung in Hagen (Disposal of Bulky Goods at Hagen). — Der Stadtetag, Issue 2. 1966.

Erbel, A. Grossbehalter in der Abfallbeseitigung (Large Containers in Refuse Disposal). — Kommunalwirtschaft, Issue 1. 1965.

Erbel, A. and W. Kaupert. Müll und Abfall; Behandlung and Verwertung. (Refuse and Waste; Treatment and Utilization). — Schriftenreihe Fortschrittliche Kommunalverwaltung, Vol. 2, G.Grote'sche Verlagsbuchhandlung KG Koln and Berlin. 1965.

Fischer, F. Neue Wege der Mullabfuhr (New Methods of Refuse Removal). – Stadtereinigung, Issue 1, 1st year of publ. Bohmann Industrie-u. Fachverlag, Wien 1. 1965.

Flon, H. Les incidences de l'evolution de la composition des ordures ménagères sur le compostage. A.G.H.T.M. – Congrès de Luxembourg, 14 septembre 1965. – Techniques et Sciences Municipales, 61e année, No. 2. 1966.

Frechen, B. Das Kompostwerk Duisburg-Huckingen (The Composting Plant Duisburg-Huckingen). – Kommunalwirtschaft, Issue 9. 1965.

Fuller, W.H., and S. Bosma. The Nitrogen Requirement of Some Municipal Composts. – Compost Science, Summer, Vol. 6 No. 2. 1965

Geer, G.-L. Mullverbrennung im Dampfkraftwerk Stuttgart-Munster (Refuse Incineration in the Steam Power Plant Stuttgart-Munster). – Der Stadtetag. Issue 1. 1965.

Glockner, H., R. Franzke, and F. Klott. Oekonomische Probleme der Mietenkompostierung (I u. II) (Economic Problems of Windrow Composting). – Die ortliche Versorgungswirtschaft, Organ des Institutes fur Kommunalwirtschaft, Dresden, Issues 5 and 6. 1965.

Haller, R. Gemeinsame Verbrennung von Klarschlamm und Mull in Ebingen (Combined Incineration of Sewage Sludge and Refuse in Ebingen). – Kommunalwirtschaft, Issue 9, 1965.

Hart, S.A., and P.H. McGaughey. The Managements of Wastes in the Food Producing and Food Processing Industries. – Food Technology, Vol. 18, No. 4. 1964.

Hasler, A. Eignung von Siedlungsabfallen als Dunger (Suitability of Municipal Refuse for Fertilizer). – Schweiz. Gartenbaublatt, 86th year of publ., Issue 42, Solothurn. 1965.

Heyking von, J. Mullverwertung durch Schnellgarung nach dem Verfahren PRAT (Utilization of Refuse by Rapid Fermentation According to the PRAT Process). – Aufbereitungs-Technik, Issue 10. 1965.

Hirte, W.F. Die Erfassung von Bakterien im Boden und Kompost mit Hilfe der Tropfmethode (Detection of Bacteria in Soil and Compost by the Drop Method). – Zentralbl. f. Bakteriologie, Parasitenkunde, Infektionskrankheiten u. Hygiene, II. Abt., 119, VEB Gustav Fischer, Jena. 1965.

Hirte, W.F. Arbeitsmethoden in der naturwissenschaftlichen und technischen Mikrologie, I: Die Anwendung der Verdunnungsplattenmethode zur Erfassung der Bodenmikroflora; 1. Der quantitative Nachweis (Methods of Work in Scientific and Technical Micrology, 1. The Use of the Thinning-plate Method for the Detection of the Soil Microflora: 1. Quantitative Proof). – Zentralbl. f. Bakteriologie, Parasitenkunde, Infektionskrankheiten und Hygiene, II. Abt., 119, VEB Gustav Fischer, Jena. 1965.

Hirte, W.F., and B. Heinrich. Die Untersuchung von Anaerobiern in Kompost und Boden mit Hilfe der Uhrglasmethode (Examination of Anaerobics in Compost and Soil by the Watch Glass Method). – Zentralbl. f. Bakteriologie, Parasitenkunde, Infektionskrankheiten u. Hygiene, II. Abt., 119, VEB Gustav Fischer, Jena. 1965.

Hoffmann, W. Verwendung von Mull fur landschaftspflegerische Massnahmen (The Utilization of Refuse for Landscaping). – Der Stadtetag, Issue 1. 1966.

Horstmann, O. Leistungs- und Kostenermittlung bei der Mullabfuhr (Determination of Efficiency and Costs of Refuse Collection and Removal). – Der Städtetag, Issue 2. 1965

Horstmann, O. and W. Last. Die Kompostierungsanlage Heidelberg: Mullraspel und Multibacto-Turm (The Composting Plant in Heidelberg, Refuse Rasp and Multibacto Tower). – Kommunalwirtschaft, Issue 9. 1965.

Hurst, K. Die Mullbeseitigung in kleineren Städten und das Wasserhaushaltsgesetz (Waste Removal in Smaller Towns and the Water Economy Law). — Kommunalwirtschaft, Issue 4. 1965.

Hurst, K. Mullverbrennungsanlagen (Waste Incineration Plants). — Kommunalwirtschaft, Issue 9. 1965.

Jacke, W. Die Mullverbrennungsanlage Rosenheim (Waste Incineration Plant in Rosenheim). — Kommunalwirtschaft, Issue 4. 1965.

Jager, B. Neue Richtlinien für die Untersuchung von Müll (New Directions for the Examination of Refuse). — Aufbereitungs-Technik, Issue 5, 6th year of publ., Wiesbaden, 1965.

Ingwersen, H.-H. Betriebsergebnisse und Erfahrungen mit einem neuen Müllverbrennungsrost (Operation Results and Experience with a New Grate for Waste Incineration). — Stādtehygiene, Issue 10. 1965.

Jück. Müllkippenbetrieb (Refuse Tipcart Operation). — Kommunalwirtschaft, Issue 1. 1965.

Kampschulte, J. Anfall und Beseitigung von Hausmull und Industrieabfallen (Occurrence and Removal of Domestic Refuse and Industrial Waste). — Gesundheits-Ingenieur, 86th year of publ., Issue 2. 1965.

Kampschulte, J. Beseitigung von Haus- und Sperrmull sowie besonderen Abfallen in Hamburg (Disposal of Household Refuse, Bulky Waste and Special Waste in Hamburg). Stadtehygiene, Issue 10. 1965.

Kau, E. W. Zur Entwicklung von Einrichtungen zur Unschadlichmachung mineralolgetrankter Böden (Development of Equipment for Rendering Innocuous Soils Soaked with Mineral Oil). — Kommunalwirtschaft, Issue 8. 1965.

Kaupert, W. Bundestagung des Verbandes kommunaler Fuhrparks- und Stadtreinigungsbetriebe (Conference of the Union of Communal Transport Fleet and Town Cleansing Enterprises). — Städtehygiene, Issue 2. 1965.

Kaupert, W. 3. Kongress der I. A. M. vom 24. — 29 Mai 1965 in Trient (Third Congress of I. A. M. from 24 — 29 May 1965 in Trient). — Städtehygiene, Issue 20. 1965.

Keiler, P. Möglichkeiten des Kompost-Einsatzes im Pflanzenbau (Possibilities of the Use of Compost in Plant Cultivation). — Schweiz. Zeitschr. f. Hydrologie, Vol. 26, Fasc. 2, Verl. Birkhäuser, Basel. 1965.

Kempa, E. Klärschlamm und feste Brennstoffe (Sewage Sludge and Solid Fuels). — Jahrbuch "Vom Wasser," Vol. 31, Verl. Chemie, Weinheim/Bergstr. 1964.

Kiefer. Gemeinsame Aufbereitung von Klärschlamm und Müll (Combined Processing of Sewage Sludge and Refuse). — Stadtehygiene, Issue 8. 1965.

Kiess. Zur Entwicklung von Einrichtungen zur Unschädlichmachung mineralölgetränkter Böden (Development of Equipment for Rendering Innocuous Soils Soaked with Mineral Oil). — Kommunalwirtschaft, Issue 9. 1965.

Knie, K. Die chemische Untersuchung von Schlammen (Chemical Examination of Sludges). — Wasser und Abwasser, Band 1963: Schwebestoffe und Schlämme in Gewassern und Kläranlagen. Verl. Winkler and Co., Wien. 1963.

Knoll, K. H. Hygienische Aspekte bei der Behandlung und Beseitigung von Klärschlamm und anderen festen Abfallstoffen (Hygienic Aspects of the Treatment and Removal of Sewage Sludge and other Solid Waste). — Schweiz. Zeitschrift f. Hydrologie, Vol. 26, Fasc. 2, Verl. Birkhäuser, Basel. 1965.

Komendova, V., and B. Drabek. Physikalisch-chemische Eigenschaften der Schlämme (Physio-Chemical Properties of Sludges). — Wasser und Abwasser, Band 1963: Schwebestoffe und Schlämme in Gewässern und Kläranlagen. Verl. Winkler and Co., Wien. 1963.

Kropf, G. Erhebungen der Mullabfuhrgebuhren durch Gebührenmarken (Collection of Waste Removal Fees by Fee Stamps). — Der Städtetag, Issue 2. 1966.

Krichbaum,H. Oeffentlich-rechtliche oder privatrechtliche Benutzungsordnung fur Mullabladeplatze? (Public-law or Private-law Regulation for the Use of Refuse Dumps?). – Der Städtetag, Issue 2. 1966.

Langer,W. Die Bedeutung der schadlosen Abfallbeseitigung fur die Wasservorkommen (The Importance of Safe Waste Disposal in the Presence of Water). – Lecture at the Wasserfachliche Aussprachetagung des DVGW and VGW on 11 – 13 March 1965 in Gottingen. 1965.

Lengyel,W. Die Behandlung von stadtischem Abwasserschlamm (Treatment of Municipal Sewage Sludge). – Wasser und Abwasser, Band 1963: Schwebestoffe und Schlamme in Gewassern und Klaranlagen. Verlag Winkler and Co., Wien. 1963.

Liebmann,H. Untersuchungen über Wurmeier in Rohabwassern und Kläranlagen Japans (Examinations Concerning Helminthic Ova in Raw Sewage and Purification Plants in Japan). – Berliner und Munchener tierarztliche Wochenschrift, 78th year of publ., Issue 6. 1965.

Liepolt,R. Die biologische Bedeutung der Schwebestoffe und Schlämme (The Biological Significance of Suspended Matter and Sludges). – Wasser und Abwasser, Band 1963; Schwebestoffe und Schlämme in Gewässern und Klaranlagen. Verl. Winkler and Co., Wien. 1963.

Mahlke,H. Beseitigung von Industrieabfällen (Removal of Industrial Waste). – Kommunalwirtschaft, Issue 1. 1965.

Mayer,W. Das Blitztrocknungs- und Verbrennungssystem, ein Verfahren zur Schlammbehandlung (The Lightning Drying and Incineration System, A Sludge Treatment Process). – Aufbereitungs-Technik, Issue 10. 1965.

Maystre,Y. Expériences faites à la station de Villette (Genève) au sujet du compostage combiné de gadoues et de boues provenant de l'épuration des eaux. – Schweiz. Zeitschr. f. Hydrologie, Vol. 26, Fasc. 2. Birkhauser Basel. 1965.

Megay,K. Trübungsstoffe und Faulschlamm-Probleme aus der Sicht des Hygienikers (Turbid Matter and Problems of Digested Sludge from the Point of View of a Hygienist). – Wasser und Abwasser, Band 1963: Schwebestoffe und Schlämme in Gewassern und Klaranlagen. Verl. Winkler and Co., Wien. 1963.

Merkel,W. Stadtereinigung in Japan, 1. Teil (Town Cleaning in Japan, Part 1). – Stadtereinigung, 2nd year of publ., Issue 2, Wien I. 1965.

Meyer,H. Schweinfurter Anlagen zur gemeinsamen Behandlung (Brikollare Verfahren) (Schweinfurt Plants for Combined Treatment. Brikollare Process). – Kommunalwirtschaft, Issue 9. 1965.

Ministerio de Salud Publica, Montevideo. Conversion de los residuos y drenajes en abono fertilizante. (Contenido del informa de la comisión designada por el M. S. P. para estudiar este tema). 1964.

Montens,A. Die Verbrennung von Altol und Oelschlammen (Incineration of Used Oil and Oil Sludges). – Das Gas- und Wasserfach GWF, Wasser/Abwasser, 106th year of publ., Issue 14. 1965.

Mucke,K.H. Lästiges Abfallmaterial: Papier wird wertvoller Kompost (Bothersome Waste: Paper Becomes Valuable Compost). – Städtehygiene, Issue 2. 1965.

Muhlethaler,P. 10 Jahre Betriebserfahrungen bei der Mullverbrennungsanlage Bern (Ten Years of Experience in the Operation of the Waste Incineration Plant in Bern). – Kommunalwirtschaft, Issue 1. 1965.

Muller,H.J. Neuerungen im städtischen Fuhrpark München-Gladbach (Innovations in the Municipal Vehicle Fleet Park Munchen-Gladbach). – Der Städtetag, Issue 9. 1965.

Muller,H.J. Reststoffprobleme der Müllbeseitigung (Problems of Residues in Refuse Disposal). – Kommunalwirtschaft, Issue 1. 1965.

Muller, H.J. Müllverbrennungsanlage für Bad Godesberg (Waste Incineration Plant for Bad Godesberg). — Kommunalwirtschaft, Issue 1. 1965.

Neveux, M., and M. Mesnil. Aspect actuel de la transformation des ordures ménagères en vue de leur utilisation agricole. A.G.H.T.M. — Congrès de Luxembourg, 14 septembre 1965. — Techniques et Sciences Municipales, 61ème année, No. 1. 1966.

Niemitz, W., and K. Fuss. Der spezifische Filterwiderstand und die Kompressibilität von Klarschlämmen (Specific Filter Resistance and Compressibility of Sewage Sludges). — Gas- und Wasserfach GWF, Wasser/Abwasser, 106th year of publ., Issue 28. 1965.

Ponninger, R. Der städtische Abwasserschlamm; Anfall, Beschaffenheit und Behandlung (Municipal Sewage Sludge; Occurrence, Composition and Treatment). — Wasser und Abwasser, Band 1963: Schwebestoffe und Schlamme in Gewässern und Kläranlagen. Verl. Winkler and Co., Wien. 1963.

Poletschny, H. Die Nachrotte von aufbereitetem Frischmüll bei Zumischung von Braunkohle, Papier und Abwasserklärschlamm und die Wirkung der Komposte auf das Pflanzenwachstum (Further Decomposition of Processed Raw Refuse with the Addition of Brown Coal, Paper and Sewage Sludge, and the Effect of Composts on Plant Growth). — Diss. Landwirtschaftl. Fakultät der Rheinischen Friedrich-Wilhelms-Universität Bonn. 1965.

Pook, G. Erfahrungen auf der Müllverbrennungs- und Schlammtrocknungsanlage Glückstadt mit der gemeinsamen Verbrennung von Müll und Klärschlamm (Experience at the Waste Incineration and Sludge Drying Plant in Glückstadt with Combined Incineration of Refuse and Sewage Sludge). — Kommunalwirtschaft, Issue 9. 1965.

Reeves, J.B. Studies of Sewage Sludge and Sawdust Compost. — Compost Science, Summer, Vol. 6, No. 2. 1965.

Rohde, G. Bekämpfung der Rieselmüdigkeit (Control of Trickle Fatigue). — Zeitschr. f. d. gesamte Hygiene und ihre Grenzgebiete, 11th year of Publ., Issue 8. 1965.

Rose, W.W., J.E. Chapman, S. Roseid, A. Katsuyama, V. Porter, and W. Mercer. Composting Fruit and Vegetable Refuse. — Compost Science, Summer, Vol. 6, No. 2. 1965.

Schmitt-Tegge, J. Kostenstrukturanalysen und Wirtschaftlichkeitsuntersuchungen bei verschiedenen Verfahren zur Beseitigung kommunaler Abfälle (Analyses of Cost Structure and Examination of Profitability of Different Processes for Removal of Communal Refuse). — Schriftenreihe des Deutschen Arbeitskreises Wasserforschung e. V., Erich Schmidt-Verlag, 48 Bielefeld, Issue 7. 1964.

Schrader. Sperrmüllverbrennung in Braunschweig (Incineration of Bulky Refuse in Braunschweig). — Kommunalwirtschaft, Issue 4. 1965.

Schröder, W. Behandlung und Beseitigung des Klärschlamms (Treatment and Disposal of Sewage Sludge). — Schweiz. Zeitschr. f. Hydrologie, Vol. 26, Fasc. 2, Birkhäuser, Basel. 1965.

Sontheimer, H. Die wesentlichen Probleme der gemeinsamen Verbrennung von Klärschlamm und Müll (Essential Problems of the Combined Incineration of Sewage Sludge and Refuse). — Kommunalwirtschaft, Issue 9. 1965.

Spohn, E., Woermann and Knöfel. Glas im Kompost (Glass in Compost). — Städtehygiene, Issue 6. 1965.

Strauch, D. Klar erkannt — Gefahr gebannt; Kompostierungsverfahren experimentell getestet ("Awareness Removes Danger"; Composting Processes Experimentally Tested). — ZfK, Zeitschr. f. kommunale Wirtschaft, Issue 12 München 9. 1965

Sulzer,M. Influence sur l'incinération des ordures ménagères de l'évolution de leurs caractéristiques. A.G.H.T.M. — Congrès de Luxembourg, 14 septembre 1965. — Techniques et Sciences Municipales, 61ème année, No.1. 1966.

Thomas,G. Neuere Erfahrungen bei der Entwässerung und Verbrennung von industriellen und häuslichen Schlämmen (Latest Experiences in the Dewatering and Incineration of Industrial and Domestic Sludges). — Wasser und Abwasser, Band 1963:Schwebestoffe und Schlämme in Gewassern und Klaranlagen. Verl. Winkler and Co., Wien. 1963.

Tope. Anforderungen an Kleinverbrennungsanlagen für Hausmüll (Demands on Small Incineration Plants for Domestic Refuse). — Städtehygiene, Issue 6. 1965.

Uebbing,H. Wohin mit dem Müll? (Whither With the Refuse?). — Frankfurter Allgemeine of 27.11.1965.

Von Conrad,E. Zur Frage der Mûllaufbereitung (On the Question of Refuse Processing). — Kommunalwirtschaft, Issue 1. 1965.

Wegmann,E. Anlagen mit gemeinsamer Verarbeitung von Mull und Klärschlamm in der Schweiz (Plants with Combined Processing of Refuse and Sewage Sludge in Switzerland). — Kommunalwirtschaft, Issue 9. 1965.

Weiss,A. Die Hygiene der Müllabfuhr und Strassenreinigung (Hygiene of Refuse Collection and Street Cleaning). — Kommunalwirtschaft, Issue 4. 1965.

Wiley,J.S., and O.W.Kochitzky. Composting Developments in the United States, — Compost Science, Summer, Vol.6. No.2. 1963.

Witte,O. Neue Wege in der Müllabfuhr (New Methods in Refuse Collection). — Kommunalwirtschaft, Issue 1. 1965.

Wolfskehl,O. and E.Boye. Einwirkung abgelagerter Müllasche und Müllkompostes auf das Grundwasser (Effect of Dumped Waste Ash and Refuse Compost on Groundwater). — Schweiz. Bauzeitung, Issue 3, 84th year of publ. 1966.

Wotschke,J. Zur Entwicklung des Flammenkammer-Einschmelzverfahrens (On the Development of the Flame-Chamber Melting Process). — Brennstoff-Wärme-Kraft, Vol.17, No.8. 1965.

Wuhrmann,K. Abfallbeseitigung in mittelgrossen Verbrennungsöfen (Refuse Disposal in Medium-sized Furnaces). — Aufbereitungs-Technik, Issue 5, 6th year of publ., Wiesbaden. 1965.

Wuhrmann,K. 3.Internationaler Kongress über Beseitigung und Verwertung fester Siedlungsabfälle (Third International Congress on the Disposal and Utilization of Solid Municipal Refuse). — Aufbereitungstechnik, Issue 10. 1965.

Wylemann,E.H. Totale Beseitigung fester und flüssiger Abfälle (Total Removal of Solid and Liquid Waste). — Gewässerschutz-Lufthygiene, Plan No.3. 1965.

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COMMUNITY AND STATE TASKS IN WASTE DISPOSAL

By Ir. W. A. G. Weststrate, Staatstoezicht op de Volksgezondheid, Den Haag (Netherlands)

Problems of refuse disposal have become increasingly important during the last 10 to 20 years, and undoubtedly will become even more so. The amount of waste and bulky refuse to be disposed of increases with rising living standards. The last phase of most consumption goods is refuse, i.e., the total production of the glass, ceramics, and plastics industries finally reaches the waste bins. Public sanitation thus becomes a most important matter.

While requirements of nutrition, clothing, living space, and recreation have risen, cleanliness of towns and countryside has lessened. Refuse lies everywhere, and uncontrolled tipping accompanied by smoke, odors, and vermin is widespread. Despite technical achievements, waste disposal remains an "undeveloped area" which must be altered. Improved technical means are available to meet the larger problems and they need only be used. Although much capital is being invested in refuse incineration and composting plants, as well as in controlled tipping, it is still insufficient.

The prediction may be made that in 20 years the total volume of refuse in Western Europe will probably be three times as great as it is today. At the end of the century, the refuse weight will probably be three times as great as today. Thus, the task of communities will continue to increase, as will their responsibility for properly collecting, processing, and disposing of the refuse. These problems might become too great for small communities which cannot afford experts and expensive machinery. These communities in particular, and many others, too, could profit from an information service supplying data on controlled tipping, incineration, and composting, as well as on the advantages and disadvantages of different methods, and information on problems of costs. A consulting authority, assisting the communities and concerned with regional planning, would even be more helpful.

Rapid progress in refuse removal methods gives rise to certain problems which can be solved only through research and development. Sanitation departments and health offices should have a collective research center, just as other important industries have. Private firms allocate up to 5% of their budgets for research and consider this necessary. A small research budget, therefore, would also be desirable for public enterprises. Until now, the sanitation expert's work has been considered purely practical and not requiring any scientific foundation. Persons dealing with refuse usually have acquired the necessary know-how on their own. Problems of waste disposal, in particular those concerned with tipping, have been studied far less intensively, except in the U. S. and Great Britain, than those of sewage purification

Another difficulty is to obtain the required personnel. Work in sanitation is not greatly in demand, so that unsuitable persons usually apply for positions in all grades. The manager of the vehicle fleet of a large city recently asked, "Who will take our place when the present generation disappears?" The status of sanitation workers is not very

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high. This is peculiar, as public service elsewhere is in high esteem. Is this because the work was done formerly by prisoners and criminals, or because of the work itself? A housewife or nurse performs dirty and unpleasant work without harm to her status. It is very difficult to raise the low esteem in which the work is held, but for social and hygienic reasons the state has the duty of eliminating this prejudice. Study courses comprising practical and theoretical training for experts in all grades might be very helpful in this aspect.

The problems here considered are only a few of many. They have been discussed in many countries; practical steps are being taken in some of them, e.g., training experts in Britain, and consulting authorities in the Netherlands and in Switzerland. In Germany, a central authority for waste disposal recently has been set up by the Federal Government together with the states. This authority will establish principles and guidelines, collect information, assemble statistical data, and work out proposals for coordinating research work. A new law (Solid-Waste Disposal Act) was passed in the U. S. in autumn 1965, according to which the Federal Administration is authorized to spend 91.5 million dollars until July 1969 on research, testing, preliminary and advanced training, subsidies, and planning in the field of waste disposal. These countries, then, are taking over central authority for those tasks which the communities cannot fulfill.

Problems of hygiene are again arising in towns and countryside, although the epidemics of previous centuries have long been overcome. The increase in wealth causes the quantity of waste to mount like an avalanche until it affects the purity of water, soil, and air. The higher standard of living should also be reflected in cleanliness and hygiene. This, however, is not the case. The American economist, J. R. Galbraith, said, "The greater the wealth, the thicker will be the dirt." It is the duty of communities and states to prevent this. Everybody should be able to live in a clean town and a protected countryside.

EFFECT OF BORON IN REFUSE COMPOST

Communication of the Eidg. Agrikulturchemische
Versuchsanstalt Liebefeld-Bern
By Dr. A. Hasler and Dr. R. Zuber

1. Boron as Plant Nutrient

In the light of cultivation experience gained so far in Switzerland, boron is the micronutrient obtained by plants from the soil, most frequently in insufficient quantities. Sugar beet heartrot and dry rot are probably the most widely known boron deficiency symptoms in agriculture. Boron deficiency symptoms are a problem also in fruit and vegetable growing. Various plant species, however, have widely differing requirements for boron. Boron as micronutrient is highly efficient, which brings the boron-deficiency and -poisoning limits fairly close to one another. Certain plant species, however, have differing tolerance limits depending, according to Oertli and Kohl (1961), on the particular traveling velocity of boron in the sap circulation. Results of spinach and bush bean cultivation tests in a neutral, humus-type, feebly sandy loamy soil have shown how differently plants react to the same boron content of the soil. The soil was known to be poor in boron;

before fertilizing, it contained 0.15 ppm available boron. Increasing amounts of boron were then added by applying a borax solution containing from 1 to 16 ppm boron. As compared to the (boronless) control, spinach showed better growth at any dosage. No signs of overfertilizing could be detected (Figure 1).

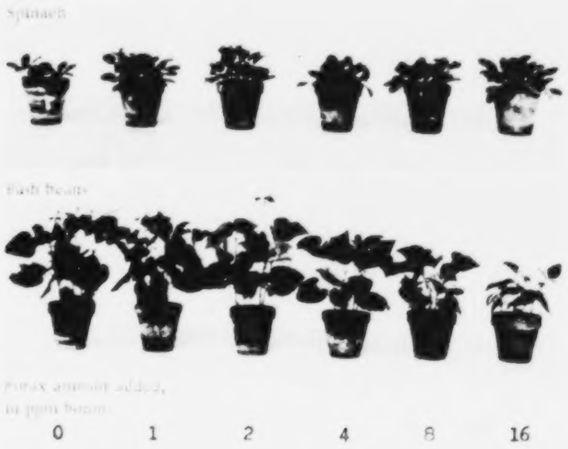

Spinach
Bush beans
Borax amount added,
in ppm boron
0
1
2
4
8
16

FIGURE 1. Influence of increasing boron doses (in form of borax) on spinach and bush beans cultivated in a neutral, sandy loamy soil.

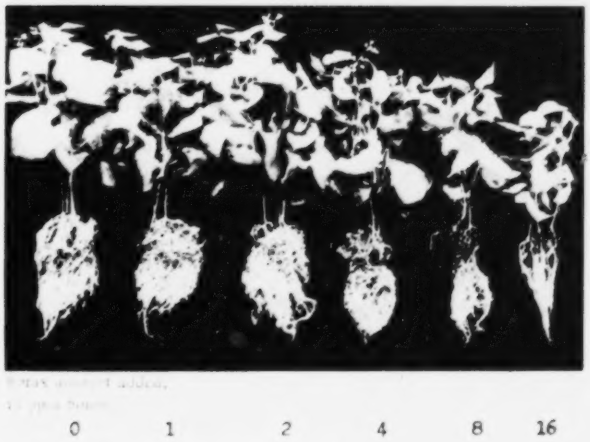

Borax amount added,
in ppm boron
0
1
2
4
8
16

FIGURE 2. Effect of increasing boron doses (in form of borax) on development of bush bean roots

Bush beans, however, behaved differently. Very small boron amounts slightly promoted their development, but higher boron amounts inhibited growth, and even led to the appearance of necrotic spots on the leaf surfaces. The development of bush bean roots was also adversely affected by higher boron doses, formation of nodules being strongly inhibited and even completely suppressed (at highest boron doses) (Figure 2).

2. Assessment of Boron Content of Soils

The available boron supply of a soil is assessed by determining the hot water-soluble amount of boron. Lowest requirement for adequate supply is 0.35 ppm boron. Accordingly, boron is the most frequently lacking micronutrient in the Austrian subalpine soils (Schiller, 1961). More than 90% of the German soils have an insufficient supply of boron (Schachtschabel, 1955). Rohde (1962) considers 90% of the microelement-deficiency phenomena in cultivated plants in Germany to be the effect of boron deficiency. Judging from the above limits, a great part of agricultural land in Switzerland especially in the central and subalpine regions, has an insufficient boron supply. Studies of the soil in the areas around the Aarberg sugar refinery also indicated that sugar beet land regularly fertilized with boron-containing stable manures contained ca. 0.45 ppm boron, whereas unfertilized soils contained only 0.25 ppm boron. According to various authors, the content of readily available (hot-water soluble) boron in the soil is only about 5 % of the total boron content. The utilization factor is mostly low even after application of moderate amounts of water-soluble boron (ca. 20 kg borax/ha), as most of the boron in soil is fixed and hardly accessible to plants (Pfaff et al. 1955, Barbier 1963). To fertilize boron-poor soils in the Austrian subalpine areas, Schiller (1961) therefore recommends 200 kg/ha borax doses, to be distributed over 4 years, however.

Fixation of water-soluble boron, as well as of other micronutrients introduced into the soil by fertilization, is influenced mainly by soil reaction, and also by the type and amount of inorganic adsorbents (clay minerals, iron and aluminum hydroxides). Investigations by Hasler and Zuber (1961) have shown that boron fixation increases (and the amount of available boron correspondingly decreases) approximately from pH = 6 to pH = 8 or 8.5.

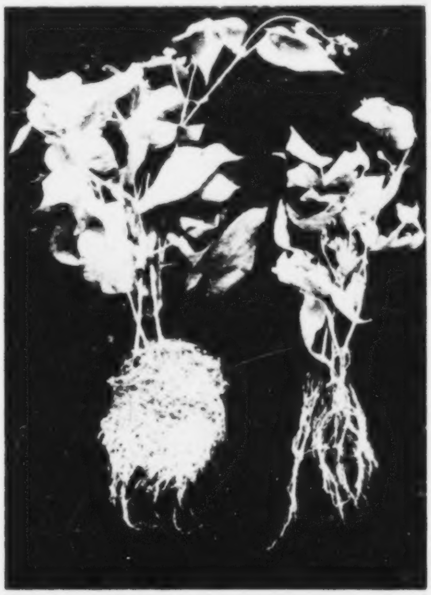


FIGURE 3. Influence of 1 and 16 ppm boron (in form of borax) on the formation of bush bean root nodules.

3. Nutrient Content, Especially Boron Content, in Refuse Compost

The fact that communal refuse contains not only organic matter but also plant nutrients has led to its utilization as a fertilizer, either fresh or composted.

Many tests have shown that, given proper application, such refuse and its decomposition products, in meeting certain requirements (Gisiger, 1958) can contribute to the improvement of the physicochemical conditions in many soils. According to Geering (1964), communal refuse composts should be utilized as far as possible for intensive cultivation of vineyards, orchards and special crops, where their efficiency is higher than in ordinary farming. By and large, communal refuse and its processing products contain approximately the same amounts of major nutrients as farmyard manure. The efficiency of nitrogen and phosphorus in refuse compost (RC) and refuse-sewage-sludge compost (RSSC) is, however, much lower than in farmyard manure (Hasler, 1965).

As compared with farmyard manure, RC and RSSC generally contain much higher amounts of various nutrients (Table 1).

TABLE 1. Total micronutrients in farmyard manure and in communal refuse

Micronutrient		According to our investigations, farmyard manure with 20% dry matter contains about		According to data from literature, RC and RSSC, respectively, with 60% dry matter, contain	
		mg/kg	kg per 50 tons	mg/kg	kg per 50 tons
Boron	(B)	8	0.4	14 – 360	0.7 – 18.0
Manganese	(Mn)	18	0.9	80 – 630	4.0 – 31.5
Copper	(Cu)	6	0.3	52 – 940	2.6 – 47.0
Zinc	(Zn)	25	1.25	42 – 1,260	2.1 – 63.0
Molybdenum	(Mo)	0.5	0.025	ca. 12	ca. 0.6

The effective amounts of micronutrients in RC and RSSC, however, make up only a fraction of the total amounts. Nevertheless, the effective amount of micronutrients in refuse compost in general is considerably higher than in farmyard manure. This applies particularly to the micronutrient boron which is present in many agricultural soils in insufficient amounts only.

Keller and Halter (1960) investigated therefore large quantities of refuse composts and refuse-sewage-sludge composts of different origin as to their boron contents. The analyzed samples contained in dry matter 27 – 179 ppm total boron and 1.8 – 27.7 ppm available (hot-water soluble) boron. The highest amount of soluble boron (27.7 ppm) was contained in compost from winter refuse. Doses of even 100 tons/ha of this compost with 40% water contain only 1.68 kg soluble boron corresponding to 14.8 kg borax/ha.

Content of boron and other plant nutrients in compost depend on the type of refuse and its chemical composition. Lignite and wood ashes are relatively rich in boron. In various samples of coal ashes Rohde (1962) detected 6.2 to 23.8 ppm hot water soluble boron. The writers have found even considerably higher (up to 120 ppm) amounts of effective boron in furnace and chimney soot. Owing to the conversion of heating installations from coal to oil firing and to the increasing automation of laundries the ash yield is decreasing, leading to a corresponding drop in the boron contents of communal refuse composts. Results of analyses of two composts from summer and winter refuse are given in Table 2. The boron contents of both decomposition products are almost identical.

TABLE 2. Contents of nutrients in two composts prepared from summer (I) and winter (II) refuse

Contents		Compost I	Compost II
Ash	%	57.5	73.7
Organic matter	%	42.5	26.3
N	%	1.40	0.96
P_2O_5	%	0.95	0.87
K_2O	%	0.43	0.45
Ca	%	6.90	10.2
Mg	%	0.62	0.77
Water-soluble boron*	ppm	10.3	10.2
Total boron**	ppm	22.6	24.4

* Extract in hot water.

** Extract in 20% HCl after preliminary calcination.

An important difference between the composition of farmyard manure and that of RC and RSSC composts lies in that the average calcium contents (mainly carbonate) of the latter are much higher that those of manures. The contents vary approximately between 5 and 15% $CaCO_3$. Higher doses of communal refuse or composts may thus significantly raise the pH of a soil.

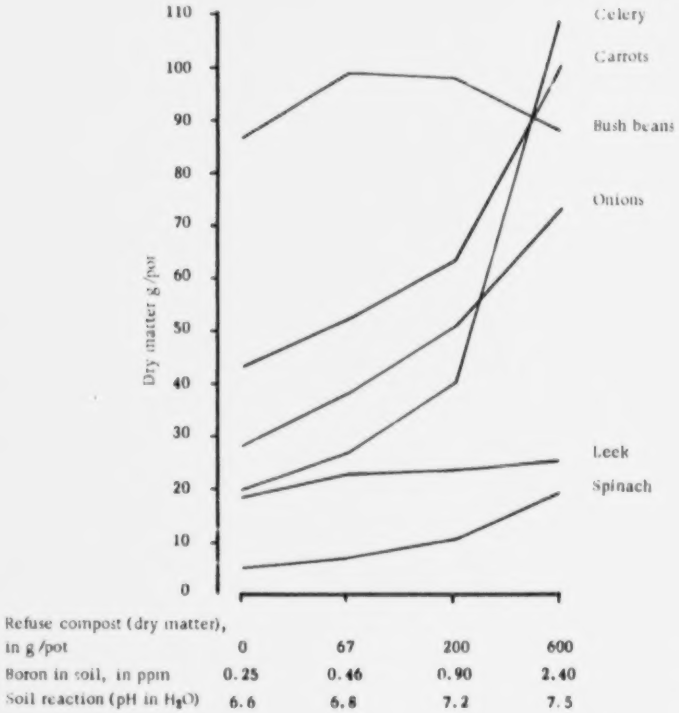
4. Tests of the Effect of Boron in Composts

Under certain conditions and owing to the consequent stronger fixation of the various micronutrients, this alkalin shift of the pH-value is considered a disadvantage in the use of refuse compost, particularly in fruit and vegetable growing. An experiment with increasing amounts of well maturated refuse compost without additional mineral fertilizer for various vegetable species has shown that all the vegetable species (except leek and bush beans) profited even from highest amounts of compost (Graph 1).

Since the compost contained 16 ppm boron, increasing amounts of compost raised not only the pH-value, but also the effective-boron content of the soil. No visible signs of overdosage were produced by even the highest concentration of 2.4 ppm boron, except for slight yellowing of bush bean leaf edges. Celery profited most from highest compost doses and showed a strikingly healthy and strong growth.

Various crops such as oats, barley and wheat, and colza still showed very good effects with 600-g compost doses per pot (1,800 q/ha) on their development and dry-matter yield (Hasler, 1965).

In practice, boron is applied to the soil as borax or boron-containing mixed or complex fertilizers. To combat acute symptoms of boron deficiency, borax or boric-acid solutions can also be used as leaf fertilizers. The boron distribution in the soil is important in determining the adequate boron doses as soil fertilizer. A sugar beet yield of 500-q beets and 300-q leaves withdraws about 400 to 600 g boron from every ha of land. The usual 20-kg dose (2.2 kg boron) approximately carries the four- to sixfold amount. The unused boron is available to the subsequent cultures, if not fixed or washed out by precipitations (Peyer, 1962). With good distribution of boron, however, lower doses of available boron may suffice, according to Henkens (1965), to cover the requirements of even more exacting crops; the varying effect of various experimental calcium fertilizers could clearly be ascribed to the available-boron contents (Truninger, 1940). Although the particular active Jurassic marls contain only about 4 ppm (50 ppm total) water-soluble boron (Hasler, 1942), they have proved surprisingly superior to other calcium fertilizers, but only at very high doses of up to and beyond 200 q/ha, in bringing about a meliorative liming. The available boron applied to the soil in linkage with marl and carrier is probably less strongly fixed by the soil than boron in water-soluble compounds (such as boric acid, borax). Moreover, a larger amount of carrier furthers good distribution in the upper soil layers, so that even the smallest amounts of boron remain active. The compost amounts applied in practice to every unit area guarantee uniform distribution of their boron content.



GRAPH 1. Effect of increasing amounts of refuse compost on dry-matter yield of various vegetable species (pot experiment)

In comparison with the initially mentioned literature data on utilization of boron, the utilization factor for boron in refuse compost is very good, as proved by vegetation tests with white clover.

The experimental soil, a weakly humous, sandy loam of pH = 5.8, contained only 0.1 ppm water-soluble boron. Two composts were employed, whose contents differed considerably in certain aspects (see Table 2). Their hot-water soluble and

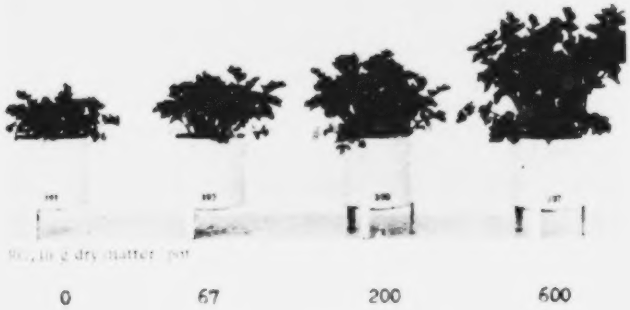


FIGURE 4. Effect of increasing doses of refuse compost (RC) on celery development

TABLE 3. Extraction of water-soluble boron from two refuse composts by white clover (pot experiment)

Compost doses per ha		pH-value of the soil after end of test	Dry-matter yield of white clover (2nd harvest), in g/pot	ppm boron in dry matter of plant	Boron extracted by white clover		Amount of boron per ha applied with the compost		Percentage extracted from the water-soluble boron in the compost
					in mg/pot	in equivalent kg/ha	water-soluble boron, in kg	equivalent amount of borax, in kg	
Compost I	600 q	6.4	44.8	24.2	1,084	0,345	0.655	5.8	53
Compost II	1,200 q	6.6	50.4	21.9	1.104	0,351	1.310	11.5	27
Compost II	600 q	6.7	43.3	20.7	0,896	0,285	0.650	5.7	44
Compost II	1,200 q	7.1	39.7	19.6	0.778	0,247	1.300	11.4	19

total boron contents, however, were strikingly similar. By its humous and ash contents, compost I corresponded to a decomposition product of summer refuse, and compost II to that of winter refuse. Two different doses were applied, corresponding to 600 to 1,200 q/ha, respectively. The different carbonate contents of the two composts caused different soil reactions; specifically, compost II acted more strongly neutralizing an equal amount of compost I, as shown by pH-values measured after completion of the tests (see Table 3). With increasing soil alkalinity, a slight drop in boron content of the dry matter of the plant is noticeable. The effects of the two decomposition products on the plant yield are also strikingly different. While approximately the same dry-matter yields were obtained at small doses, a double dose of compost I significantly raised the yield; an increased amount of compost II, however, reduced the yield. As a result of the lower boron content and reduced yields in tests with compost II, less boron was extracted than in fertilization with compost I. Relating the boron withdrawal to the boron amounts applied with the compost doses, the boron utilization factors in Table 3 are obtained.

At small compost I and compost II doses these factors were 53 and 44 %, respectively, and 27 and 19%, respectively, at higher doses.

Owing to the active boron amounts contained in most diverse refuse composts, and in the light of the good results obtained with vegetation tests, an overdose is even when large quantities of boron is not likely to produce any damaging effect (1,000 to 2,000 q/ha) of matured compost are applied, except in the case of highly sensitive plants (such as bush beans).

On the other hand, the question arises whether with application of low compost amounts an additional boron dose in the form of commercial fertilizers would be effective or not. To obtain at least a rough idea about this problem, the effect of one low and one high borax amount was studied in a pot experiment, under simultaneous application of compost. Test plants were bush beans as first crops, and spinach as aftercrop. Like all Leguminosae, bush beans have certain requirements for boron supply. As already indicated, the admissible boron-concentration range is very narrow for this plant, as opposed to spinach. Three different composts were employed (garden compost, RC and RSSC), singly and in association with borax. The compost doses applied were 100 g dry matter per pot, and the boron amounts of 7.2 and 21.6 mg corresponded to 20 and 60 kg per ha, respectively.

Table 4 gives data on the nutrient contents of the composts applied, while Table 5 lists the major properties of the two experimental soils. A comparison of these data shows that the two soils had very similar properties, except for their pH-values and the degrees of calcium saturation.

TABLE 4. Nutrient contents in dry matter of the composts applied

Contents		Garden compost	Refuse compost (RC)	Refuse sewage-sludge compost (RSSC)
Ash	%	84.3	57.9	58.3
Organic matter	%	15.7	43.0	42.7
N	%	0.712	0.785	1.052
P_2O_5	%	0.772	0.806	1.031
K_2O	%	0.693	0.302	0.333
Ca	%	8.190	3.727	4.509
Carbonate content, as $CaCO_3$	%	16.1	3.9	4.9
Mg	%	0.401	0.356	0.456
Water-soluble boron*	ppm	20.6	14.7	12.5
Total boron**	ppm	33.9	25.1	29.2

* Extract in hot water

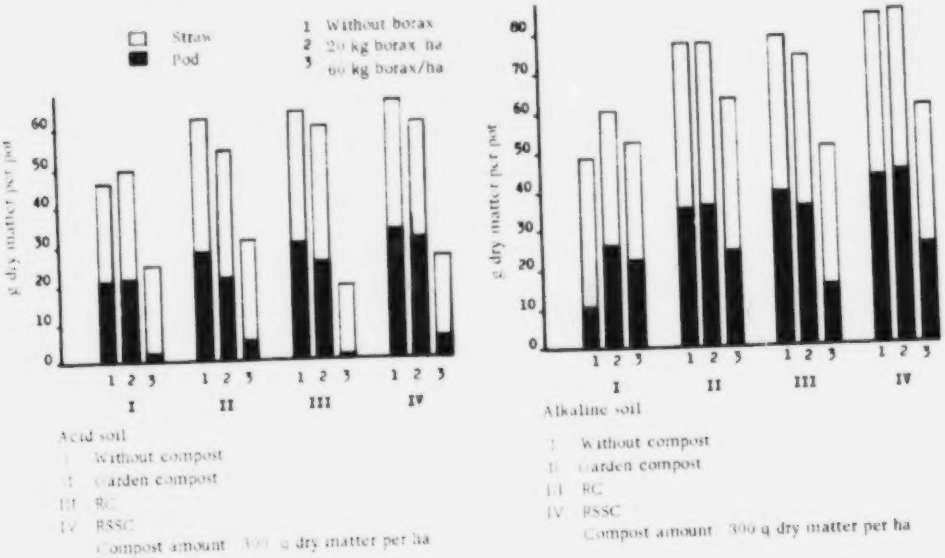
** Extract in 20% HCl after preliminary calcination

TABLE 5. Experimental results of boron-fertilization of soils

	Acid soil	Alkaline soil
pH (H_2O)	4.8	7.6
$CaCO_3$	0	0.75
Humus	2.4	2.9
Soluble in water saturated with CO_2: P_2O_5 test factor	0.5	1.5
K_2O mg/100 g	0.8	0.6
Hot water soluble boron	0.15	0.10
Cation-exchange capacity	9.2	11.7
Degree of base saturation (according to Kappen)	39.1	93.0

Classification: weakly humous sandy loam soils.
The alkaline soil was taken from a plot that had been limed 15 years before.

Each test procedure was repeated thrice. Before insemination each pot received 1 g nitrogen (as ammonium nitrate), 1 g phosphoric acid, and 1.3 g potassium as secondary potassium phosphate. After harvesting the bush beans, each pot again received 1 g nitrogen and 1 g potassium as potassium nitrate and ammonium nitrate in solution. The bush-bean yields are shown in Graph 2.



GRAPH 2. Effect of borax additions to various composts on dry-matter yield of bush beans (pot experiment)

With bush beans the compost doses had a definitely strong effect on the dry-matter yield of both pods and straw, in the acid soil as well as in the alkaline soil. Moreover, a boron-compost interaction could be detected in the pods both in the alkaline and in the acid soil. In straw, a reciprocal effect of the two fertilization factors could be detected in the acid soil only, as can be seen from the following calculations:

		Boron fertilizers (B)		Compost (C)		Interaction (BC)	
		F-Test	Eval.	F-Test	Eval.	F-Test	Eval.
Pods	acid soil	304.107	•••	18.629	•••	3.9099	••
Straw	acid soil	126.539	•••	22.310	•••	9.983	•••
Pods	alkaline soil	6[illegible].828	•••	72.322	•••	22.477	•••
Straw	alkaline soil	33.[illegible]	•••	27.452	•••	2.1104	(-)

(-) Insignificant
•• Significant to the 0.01 confidence limit
••• Significant to the 0.001 confidence limit

Compost brings about remarkable pod-yield increases in the acid and, above all, in the alkaline soil. The same applies to the straw production in the acid soil, whereas the effect of compost fertilization on the straw yield is far less important with an alkaline soil reaction. In the acid soil, a normal boron dose (without compost) caused only a fortuitous slight rise in the pod yield. Simple boron fertilization with simultaneous application of compost in the acid soil had a damaging effect on fruit development, and practically no effect on the latter in the case of alkaline soil reaction. The experimental results also indicate that a normal boron dose, with or without compost, influences the dry matter yield of straw far less than the pod yield. In the acid soil a treble boron dose was definitely prejudicial to the straw and mainly to fruit formation. In the case of simultaneous compost fertilization, the treble boron dose caused great pod-yield losses in the alkaline soil as well. The unfavorable effect of high boron doses on straw development was considerably reduced by additional fertilization.

These tests prove that in acid as well as in alkaline soils of low boron content, application of such compost amounts (100 g dry matter per pot or 300 q per ha) with a supplementary boron dose of 20 kg borax to plants such as bush beans that do not need or tolerate high amounts of boron can be expected to have an adverse effect. To improve the NPK supply in fields recently fertilized with refuse compost, it is advisable, therefore, to choose boron-free mineral fertilizers, unless the crops particularly need or tolerate boron, as spinach does. Table 6 presents the yields of spinach planted as an aftercrop to bush beans.

TABLE 6. Aftereffects of various composts and increasing borax doses on the spinach yield (fresh and dry matter, in g per pot)

	Acid soil			Alkaline soil		
	B_0	B_1	B_3	B_0	B_1	B_3
Fresh matter						
without compost	0	0	0	0	4.1	11.2
" garden compost	17.9	26.6	12.3	0.8	22.5	22.8
" refuse compost I	3.9	4.5	6.3	8.8	20.1	28.9
" refuse-sewage-sludge compost II	2.6	2.9	11.7	13.7	26.9	30.3
Dry matter						
without compost	0	0	0	0	0.8	1.1
" garden compost	1.5	2.4	1.1	0.1	2.7	3.2
" refuse compost I	0.6	0.6	0.8	0.9	2.8	3.7
" refuse-sewage-sludge compost II	0.4	0.5	1.3	1.6	3.1	4.1

B_0 = without boron

B_1 = simple boron dose 7.2 mg boron per pot, corresponding to 20 kg borax per ha

B_3 = treble boron dose 21.6 boron per pot, corresponding to 60 kg borax per ha

With spinach, the scattering of repeated-test results was very high. The calculations given below indicate, however, that a clear effect of fertilization could nevertheless be partly established.

Compost doses had a good aftereffec n in the acid and in the alkaline soils. Boron fertilizers had no ensured effect on the spinach yield in the acid soil, but only

	Boron fertilizers (B)		Compost (C)		Interaction (BC)	
	F-Test	Eval.	F-Test	Eval.	F-Test	Eval
Acid soil	1.158	(-)	12.722	***	1.312	(-)
Alkaline soil	35.716	***	17.284	***	1.518	(-)

in the alkaline soil. There was interaction here between boron and compost, as could be detected in the case of bush beans. The values listed in Table 6 show that young spinach plants in the (compostless) acid soil with or without boron fertilization failed immediately after germination, probably owing to the strongly acid soil reaction.

TABLE 7. pH-values(H_2O) of the soils with different experimental procedures (as measured after harvesting the spinach)

	Acid soil			Alkaline soil		
	B_0	B_1	B_3	B_0	B_1	B_3
Without compost	4.7	4.7	4.8	7.5	7.4	7.4
+ garden compost	6.4	6.3	6.4	7.7	7.6	7.6
+ refuse compost	6.0	5.9	6.0	7.6	7.5	7.6
+ refuse-sewage-sludge compost	5.9	6.0	6.1	7.5	7.5	7.6

The pH-values measured after harvesting the spinach (Table 7) show that the effect of the compost doses on the increase of these values was very strong in the acid soil, but expectedly insignificant in the alkaline soil. The greatest change in the pH-value was caused by garden compost, which had the highest content of alkaline-active substances among the three composts. As compared with the other two compost types, garden-compost procedure resulted partly in considerably better yields in the acid soil; this fact may probably be ascribed to the soil reaction, which held better promise for the spinach. Moreover, the procedure with the simple borax dose had the best effect on the yield in the acid soil with garden compost, whereas in the case of RSSC best aftereffect was produced by the highest borax dose. Yield figures indicate that compost doses mainly RC and RSSC were effective also in the alkaline soil, particularly so with the procedures using highest borax doses.

Summary

Refuse composts (RC) and refuse-sewage-sludge composts (RSSC) contain varying amounts of hot-water soluble, i.e., available boron. Different sources indicate contents of approximately 1 to 30 ppm boron, in relation to dry matter. The boron contents in the RC and RSSC employed by the writers in their vegetation tests fluctuated from 10.2 to 16 ppm. The boron amounts applied when using large compost doses of 120 tons (dry matter, with 10.2 ppm boron) correspond to the boron content of about 11 kg crystalline borax. The boron doses applied in relation to the compost amount can be distributed in the soil better than with application of the same amount of boron in form of borax or boron-containing commercial fertilizers. Results of vegetation tests show the boron utilization of RC to be good.

Boron-sensitive crops, such as bush beans, should receive moderate amounts of compost. Even if small RC and RSSC doses are applied to such crops, additional fertilizers with boron-containing commercial fertilizers is not advisable. Other plants, such as spinach and celery, however, tolerate without damage large amounts of RC and RSSC. Spinach is particularly tolerant of high boron concentrations.

Bibliography

1) Barbier, S. Untersuchungen an zwei Boden mit geringer Fruchtbarkeit (Investigation of Two Soils of Poor Fertility). – Die Bodenkultur, Vol. 16, pp. 25 – 40. 1965.

2) Geering, J. Ueber den landwirtschaftlichen Nutzwert von Abfallstoffen nach Ergebnissen von Gefass- und Feldversuchen (Agricultural Utilization Factor of Refuse, in the Light of Results of Pot and Field Experiments). – Schweizer. Landw. Forschung, Vol. 3. pp. 277 – 317. 1964.

3) Gisiger, L. Kehrichtkompostierung und an sie zu stellende Forderungen (Refuse Composting and Requirements). – Schweizer. Landw. Monatshefte, Vol. 36, pp. 385 – 396. 1958.

4) Hasler, A. Ueber den Borgehalt von Boden und Gesteinen (Boron Contents of Soils and Rocks). – Landw. Jahrb. der Schweiz, Vol. 56, pp. 486 – 498. 1942.

5) Hasler, A. Eignung von Siedlungsabfallen als Dünger (Adequacy of Urban Refuse as Fertilizer). – Schweizer. Gartenbau-Blatt, Vol. 15, No. 42. 1965.

6) Hasler, A. and R. Zuber. Ueber die Boraufnahme und das Kalzium: Bor-Verhaltnis in verschiedenen Futterleguminosen (Boron Uptake and Calcium: Boron Ratio in Various Fodder Leguminosae). – Schweizer. Landw. Monatshefte, Vol. 39, pp. 2 – 15. 1961.

7) Henkens, Ch. H. Richtlinien fur die Dungung mit Spurenelementen in Holland (Directions for Fertilizing with Trace Elements in the Netherlands). – Landw. Forschung, Vol. 18, pp. 108 – 116. 1965.

8) Keller, P. and Halter, R. Der Bor- und Manganmangel von Müll- und Müllklarschlammkomposten (Boron and Manganese Deficiencies in Refuse and Refuse-Sewage-Sludge Composts). – Informationsblatt der I. A. M., No. 8, pp. 8 – 12. 1960.

9) Oertli, J. J. and H. C. Kohl. Some Considerations about the Tolerance of Various Plant Species to Excessive Supplies of Boron. Soil Sc., Vol. 92, pp. 243 – 247. 1961.

10. Peyer, K. Ueber den Borbedarf landwirtschaftlicher Kulturpflanzen (Boron Requirements of Agricultural Crops). – Mitteil. f. d. Schweizer. Landwirtschaft, Vol. 10, pp. 81 – 88. 1962.

11. Pfaff, C., H. Roth, and A. Buchner. Zur Dungung mit Mikronahrstoffen. (On Fertilization with Micronutrients). – Landw. Forschung, Vol. 7, pp. 73 – 79. 1955.

12. Rohde, G. Ruckstände aus Heizungsanlagen in der Kompostierung. (Residues from Heating Plants in Composting). – Der Städtetag, Vol. 15, pp. 491 – 498. 1962.

13. Schachtschabel, P. Der Nahrstoffgehalt des idealen Bodens (Nutrient Content of the Ideal Soil). – Landw. Forschung. Sonderheft, Vol. 6, pp. 50 – 63. 1955.

14. Schiller, H. Die Bor-, Magnesium- und Manganversorgung der Böden im oberösterreichischen Alpenvorland (Boron, Magnesium and Manganese Supply of the Upper Austrian Subalpine Soils). – Die Bodenkultur, Vol. 12, pp. 181 – 189. 1961.

15. Truninger, E. Der Borgehalt des Mergels als Ursache der verschiedenen Düngwirkung von gemahlenem Kalkstein und Mergel (Boron Content in Marl as Cause of the Varying Fertilizing Effects of Ground Limestone and Marl). — Landw. Jahrbuch der Schweiz, Vol. 54, pp. 689 — 705. 1940.

*COMPOSTING OF UNDIGESTED SEWAGE SLUDGE**

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With the progress of civilization and rising standard of living, an increasing number of towns and settlements are connected to sewerage systems. Since sewage can be transported economically over limited distances only, the number of small sewage disposal plants is increasing. These often cannot ensure low-cost digestion of the fresh sludge.

Purification basins then also act as open digestion tanks.

According to the length of time it remained in the basin, the sewage sludge released periodically is more (lower layers) or less (upper layers) digested.

This sewage purification method is also applied in extensive sewage farming areas, such as those still existing in Berlin.

Owing to its comparatively high nutrient content, sewage sludge from sludge drying beds is delivered in spadable form as fertilizer for agriculture and horticulture.

TABLE 1. Analysis of spadable, undigested sewage sludge from various sludge drying beds in the surroundings of Berlin (1957-1958)

Dry matter content	28.4 — 46.6 %
Of which	
Organic matter (calcination losses)	37.9 — 73.9 %
Total N	1.67 — 3.49 %
NH_4-N	0.04 — 0.66 %
NO_3-N	0.01 — 0.02 %
Total -P_2O_5	1.09 — 2.71 %
Total -K_2O	0.05 — 0.66 %
Total -CaO	2.62 — 6.30 %

For hygienic reasons, the use of undigested sewage sludge as fertilizer in agriculture and horticulture is to be strictly avoided, although it is still practiced in many places.

Sewage sludge may contain live eggs of all sewage parasites (hookworms, bellyworms and tapeworms), as well as the germs of anthrax, typhus, tuberculosis, spinal poliomyelitis, amoebic dysentery, cholera, paratyphoid B, leptospirosis and infectious hepatitis (7, 12, 13, 17, 18). Strauch and Knoll (20) report on recently identified cases of paratyphoid B in cattle, cattle-mange infection and infection with Salmonella enteritis after the use of sewage and sewage sludge.

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* This article is a comprehensive abstract from the opening lecture "Problems in composting of undigested sewage sludge," given at the Agricultural and Horticultural Department of the Humboldt University, Berlin, in 1961. The writer wishes to express his sincere thanks to Dr. Rohde for his advice in the preparation of the lecture.

Sewage sludge, undigested or even digested, therefore, is to be considered a potential source of infection. When it is used as fertilizer, there is danger of diseases and epidemics developing and spreading.

Author's own experiments (5) have shown the fertilizing effect of sewage sludge to be not always satisfactory, often deleterious. Practical observations have corroborated this finding.

The repulsive odor of undigested sewage sludge is extremely offensive to the workers and the population in the area, during loading, unloading and spreading operations in the fields.

The tough structure of sewage sludge makes it difficult to obtain uniform distribution in the field. The writer has repeatedly observed inploughed clods of sewage sludge being brought to the surface again almost unchanged after many years. Sewage sludge spread over the soil surface loses its tough structure through free freezing in winter.

Many farmers and gardeners reject sewage sludge as fertilizer, because it may contain the seeds of many weeds. Such preventive weed control is obviously the least expensive /3/. Even spadable sewage sludge causes high transportation costs because of its high water content (55 to 65 %).

Sewage sludge in sewage drying beds freezes in winter. It cannot therefore be brought onto the fields at this laborwise favorable time of the year. Its transportation and spreading in spring is often impracticable owing to the strained labor position. Sewage sludge containing 55 to 65% water cannot be spread by stable-manure gritter, as it clogs the feed device and the spreader drum.

These shortcomings can be avoided if sewage sludge is composted together with refuse.

This is advisable wherever sewage sludge and refuse can be brought together at low cost. This has proved to be the best way, at present, of utilizing sewage sludge, particularly since refuse and sewage sludge complement one another advantageously. A way still has to be found to compost sewage sludge even where it cannot be mixed with refuse.

Composting of Sewage Sludge without Admixture

Separate composting of highly digested sewage sludge at about 50 to 60°C fails, because sewage sludge loses to a great extent its self-heating capacity during digestion, owing to degradation of readily decomposable organic matter. Without sufficiently high temperatures in compost windrows, satisfactory disinfection cannot be achieved /19/. In the present paper, the author deals only with poorly digested sewage sludge in open digesters.

In 1938, Imhoff and Muller /8/ reported on a thermophilic aerobic digestion procedure for spadable sewage sludge, which had been introduced by Kunlenz in Frankfort-on-the-Main. The fresh sludge was first predried in seepage beds and then spread in flat cakes which were subsequently stacked in fermentation piles.

These piles heated up to 70°C while their water content dropped to 15%. The dried sludge was ground to a powder and sold as fertilizer. However, this drying process was accompanied by a very bad stench (3). The flat spreading required considerable labor and space, which explains why the procedure did not find wider acceptance.

Sewage Sludge in Drying Beds

The water content of sewage sludge released from the settling tanks is reduced by percolation in the drying beds operating as filters from 95% to about 70% water. This is followed by additional drying through evaporation only; this process, however, is much slowed down by the formation of a crust on the surface of the sewage sludge. The crust starts breaking only after a certain period of time (Figure 1), but new crusts form in the cracks. During rains the sewage sludge again absorbs water, so that the water content may amount to about 70% even after prolonged deposition. No composting is possible at that water content, as the material is too compact and undergoes mainly anaerobic processes.

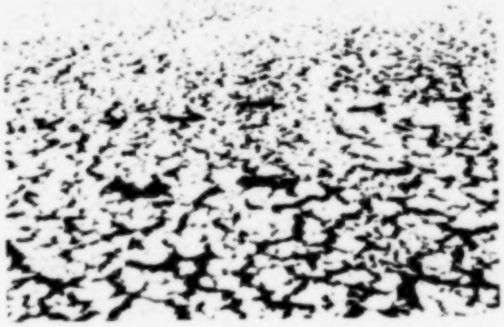


FIGURE 1. Sewage sludge deposited in drying bed, with cracked crust on surface

FIGURE 2. Drying bed covered by weeds

Careful investigations had to be carried out, therefore, concerning more rapid, additional drying of sewage sludge. Since mechanical dehydration is not possible in small plants or with bulky supplies, the sewage sludge – in accordance with the procedure recommended by Rohde /14, 15/ for composting pig excrement – should be dried by various, possibly even repeated mechanical operations, such as ploughing, harrowing, grubbering or milling to such an extent as to allow its being stacked in loose piles.

At the same time, the mechanical processing should interrupt digestion processes and trigger desirable aerobic reactions. Moreover, this operation and the accelerated drying should hamper the weed growth, which is unavoidable with long-term deposition (Figure 2).

The weeds enrich the weed-seed content of the sewage sludge and make its transportation and spreading in the field more difficult.

Although flat deposition with mechanical processing can also ensure aerobic digestion, no hygienic compost can thereby be obtained.

Sewage-Sludge Processing in Drying Beds to Accelerate Drying before Stacking in Compost Windrows

Sewage sludge can be processed in any drying bed where its layer thickness is about 15 to 30 cm.

a) Ploughing

Ploughing brings to the top the lower layer, which is characterized by high water content and intense digestion, and loosens and aerates all the material.

It is advisable to start ploughing only after the water content has dropped to about 65%, for only then can the cavities be maintained that are formed through ploughing. Sewage sludge deposited in layers up to 20 cm in height can be ploughed the first time even with about 70% water content.

Thicker layers of such water content collapse again after ploughing. A horse-driven plough is the best, as the horse can walk in the furrow (Figure 3).

FIGURE 3. Ploughing of sewage sludge in drying bed

If two horses are used, they have to be led, because the saddle horse also likes the furrow. Older and more placid horses are preferable for this operation. For the first experiments, the starting furrow was dug with a spade.

However, this proved not absolutely necessary, if a placid horse was used. If possible, the horseshoes should be removed, to avoid their getting pulled off by the viscous sewage sludge.

With the first ploughing, the sewage sludge falls apart in coarse slabs (Figure 4), similar to a clayey soil ploughed when too wet.

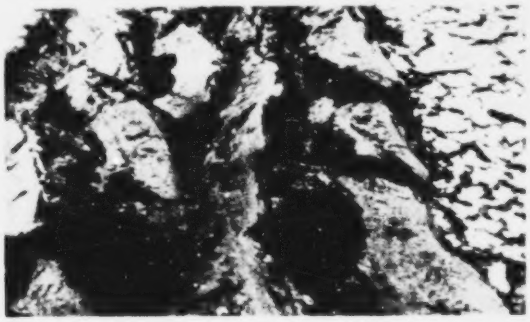


FIGURE 4. Coarse slabs after the first ploughing

At the second ploughing, which is to be carried out 10 – 14 days later, as near perpendicularly as possible to the first furrows, the structure of sewage sludge becomes more friable than at the first ploughing (Figure 5).

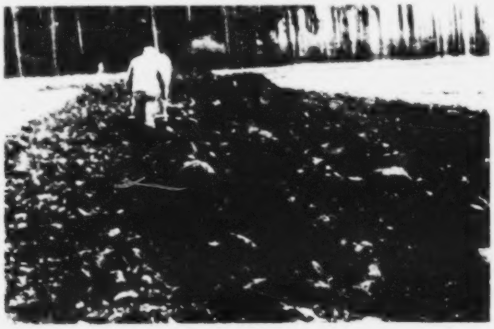


FIGURE 5. More friable structure after second ploughing

b) Harrowing

The surface of the ploughed sewage sludge hardens rapidly, particularly under powerful insolation. Hardened crumbs are hard to crush. Double harrowing at the right time can prevent the formation of hard clods (Figure 6).

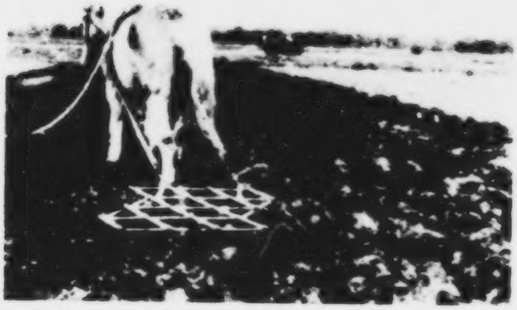


FIGURE 6. Double harrowing of ploughed sewage sludge

Right moisture content is important for harrowing. The upper layer of the sewage sludge, about 5 cm thick, must contain approximately 45 to 50% water. It can then be easily crushed in the hand, without smudging. The conditions are the same as those pertaining to the working of heavy soil. Excessive moisture causes the harrow to smudge whereas no effect is obtained if the sludge is too dry. Without preliminary ploughing the harrow has little effect, because it does not penetrate deep enough. Harrowing is necessary after every ploughing.

c) Grubbering

After the first ploughing, harrowing may be replaced by grubbering. In a way, the (rigid-tine) grubber yields better results than the harrow, as it penetrates more deeply; on the other hand, however, it leaves coarser clods.

Grubbering can also be a first operation, and offers the advantage of covering larger areas than the plough. Grubbering, however, can start only later, at about 55% humidity of the sludge. By that time, however, the bed is already covered with weeds which must first be mown thus nullifying the labor savings. It is therefore advisable to start by ploughing, whereby better turning is achieved.

d) Rototilling

Of all processing devices, the rotary cutter gives the best crumbling (Figure 7). However, the rotary cutter can be used only comparatively late, when none of the sewage sludge layers contains more than 55% water.

More often than not, the about 10-cm thick layer meets this requirement, but the layer underneath has a higher water content. In that case, the upper layer is crumbled, while the rotary cutters cut into the lower layer without moving it.

Lengthy strips then appear, whose width corresponds to the cutter spacing (Figure 8). For instance, this occurred when the 11-cm thick upper layer contained 50.2% water, while the lower 10-cm thick layer contained 63.7% water. No tilling could be effected at a water content of 32% in the 5-cm thick upper layer and 67.7% in the 15-cm thick layer underneath, because the rotary cutter sank into the sludge. The tread resistance alone of the sewage sludge in the drying bed is no indication in itself that tilling can be effected.

FIGURE 7. Rototilling sewage sludge in drying bed

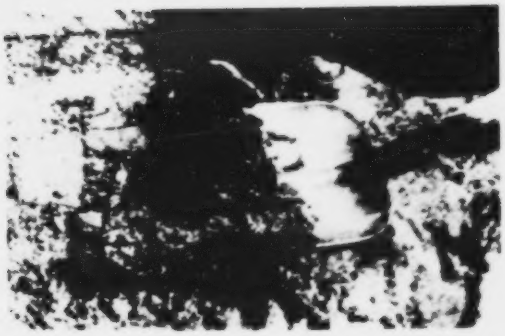


FIGURE 8. Sewage sludge with excessive water content is not crumbled by the rotary cutter, but only cut

e) Use of various devices

It has been shown here that every device used in mechanical predrying has certain advantages and shortcomings. Since it does not suffice to process the sewage sludge only once, it stands to reason that the advantages offered by the use of more than one device should be combined, and the shortcomings eliminated.

Good results were obtained by the following sequence of operations, carried out at corresponding time intervals:

ploughing - harrowing - rototilling

Ploughing is possible already at a water content of about 65%, the dry layers are thus brought underneath, while the wet ones are brought to the top. Eight to 14 days later, depending on weather conditions, harrowing is used to crush the clods and to level out the ploughed sludge. Another 8 – 14 days later, the rotary cutter crushes the sludge which has been predried by ploughing and harrowing to a water content of 50 to 55%. Occasional clods with higher water content are no obstacle. Surficial clods, however, too strongly dried out by the sun, are not crushed by the rotary cutter, but only thrown to the back.

It is advisable to wait for rain or to harrow or drag anew one day before rototilling Rototilling of the ploughed sewage sludge without intermediary harrowing is difficult and yields nonuniform results, because the milling cutter does not run horizontally over sizeable clods and therefore cannot penetrate to uniform depths

Depending on the available devices, other sequences of operations may also be used at suitable time intervals, e g.,

ploughing - harrowing - ploughing - harrowing

or

ploughing - grubbering - harrowing

or

grubbering - grubbering (crossways)

or

grubbering - harrowing

It must be stressed, however, that the best results in crushing and crumbling of sewage sludge can be achieved by

ploughing - harrowing - rototilling

(see Figures 9, 10)

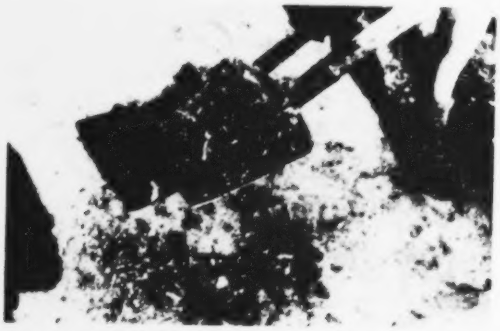


FIGURE 9. Crumbling of sewage sludge after ploughing-harrowing-ploughing-harrowing

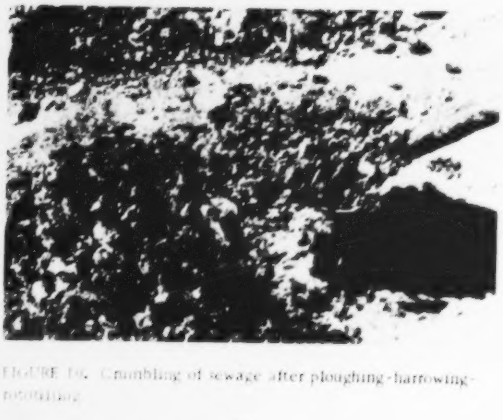


FIGURE 10. Crumbling of sewage after ploughing-harrowing-rototilling

The nonhomogeneous structure of sewage sludge at the start of the compost windrows is reflected, for some months, to a certain extent, in their structure.

Windrowing Predried Sewage Sludge

The moisture content of predried sewage sludge that is best for windrowing, the shapes and sizes of the compost windrows most suitable for that purpose, and whether or not additional aeration is necessary, should be clearly established. Several rows of predried sewage sludge of differing water contents were set up in order to determine the most suitable moisture content.

The transformation processes in those rows were checked by routine measurements of the row temperatures; besides, the appearance of anaerobic zones was recorded. Numerous measurements and observations proved that the optimum moisture content of sewage sludge for windrowing was about 50 to 55%.

In 1-m high rows the temperature at depths of 20 to 40 cm increases to 50 – 60°C within a few days.

Pathogenes and parasite eggs in the compost rows are thus killed, except for the marginal and anaerobic zones /6, 9, 10/.

Odor nuisance is hardly noticeable, particularly if much mildew develops.

The water vapor escaping from the rows can be seen clearly at low air temperature and high humidity, and the characteristic sewage sludge odor is noticeable only if an anaerobic zone has formed inside the row. The formation of anaerobic zones can be prevented by reducing the water content below 50%, but the biological decomposition of organic matter is then prematurely arrested owing to lack of water. Sewage-sludge compost rows, if set up too dry, generally remain at the mildew stage. These excessively dried compost rows are not easy to moisten by external water supply, as dried sewage repels water drops.

Anaerobic zones are most conveniently avoided by the stagewise setting-up method (StAM) /5/.

If the sewage sludge is too moist (more than 55-60% water) when piled, the rows are too tight. Owing to lack of oxygen, anaerobic zones are then formed, which start in the core of the row and often spread up to 20 cm below the surface.

Anaerobic zones, which heat up insufficiently, develop gases with pungent stench. In windrows that have been set up too wet the temperature rises very slowly; most frequently, it does not attain the hygienically necessary 55°C.

Rational Size and Shape of Sewage-Sludge Compost Rows

Several rows of differing shapes and sizes were set up. Compost windrows require a certain minimum size, to be able to attain the necessary 55 to 60°C and to limit as much as possible the marginal layers which decompose less well.

On the other hand, the higher the windrows, the greater is the pressure on their lower layers and the worse the aeration. The labor requirements for setting up windrows increase directly with the row size, because a wider strip of pedried sewage sludge must be set up in a row.

Temperature development. Aeration is best and labor requirements are lowest at a row height of about 1 m. Deviations of ± 20 cm are admissible. Temperatures of about 50°C are seldom attained in sewage-sludge compost rows less than 80 cm in height and then only at scattered spots, if at all. In rows of more than 1.20 m height, the great pressure of the sewage sludge itself favors the formation of anaerobic zones. The crumbly structure of sewage sludge that has been correctly processed mechanically, determines the angle of deposition of about 45° and thus the shape of the row. The row cross section can then be a triangle or trapezoid.

Both shapes ensure unhampered development of the decomposition processes in the compost rows; however, the height of 1.20 m and — with trapezoidal cross section — the base width of 3 m must not be exceeded.

For reasosns of labor economy, the cross-sectional shape is to be chosen in accordance with the height of the sewage sludge layer in the drying bed. Triangular 1-m high rows have a base width of 2 m. At a layer height of 20 cm such rows can be set up from a 5-m wide bed strip. A 1.5-m wide strip must be thrown over the row base in every side of the row. In this manner, two parallel rows will be separated by a 3-m interval, where vehicles can pass and be loaded from both sides.

For various sewage-sludge layer heights in the drying bed, Table 2 lists the row dimensions most favorable from the standpoint of labor economy.

TABLE 2. Shape and size of sewage-sludge compost row most favorable from the standpoint of labor economy

Sewage-sludge layer height in drying bed cm	Cross-sectional shape of row	Row height m	Base width m	Top width m	Interval between rows m
15	Triangle	0.85	1.70	-	3.12
20	Triangle	1.00	2.00	-	3.00
25	Trapezoid	1.00	2.50	0.50	3.50
30	Trapezoid	1.00	2.80	0.80	3.20

When windrows are set up with machines (e.g., the T 170 grab), this list is less important, as labor requirement increases only very little with row size. If the predried sewage sludge is composted not in the drying bed but in a special composting area, it is advisable to make the rows as large as possible. For equal digestion time, the space requirements are the lower the larger the rows are (Table 3).

TABLE 3. Space requirement for sewage-sludge compost rows of various sizes, with composting time of 6 months

Cross-sectional shape of row	Row height m	Base width m	Space requirements for 1,000 m³ windrowed sewage sludge, with 30 per cent intervals m²
Triangle	0.85	1.70	975
Triangle	1.00	2.00	650
Trapezoid	1.00	2.50	430
Trapezoid	1.00	2.80	360
Trapezoid	1.20	3.00	270

Composting time of 1 year doubles space requirements.

Provision of vertical aeration canals in the compost rows showed neither advantages nor disadvantages.

The method developed by the writer makes possible hot composting of undigested sewage sludge.

Temperatures above 55°C were attained in all set up rows according to instructions, with an optimum water content.

The composting process was completed after 3 to 4 months, the material was then ripe compost.

Digestion shrinkage after 4 months was 35 to 40% of the organic matter (calcination loss).

Table 4 shows that only little shrinkage could be detected in the organic mass after that period.

TABLE 4. Shrinkage per 100 g organic matter

Time after setting up windrows	At a depth of 20 cm in the row, g/day	At a depth of 50 cm in the row, g/day	At a depth of 90 cm in the row, g/day
1st to 3rd day	3.097	2.867	2.817
3rd to 7th day	2.825	1.555	1.443
7th to 15th day	1.550	0.796	0.438
15th to 20th day	2.560	1.622	2.522
20th to 28th day	0.280	0.540	0.513
28th to 82nd day	0.029	0.321	0.112
82nd to 97th day	0.033	0.158	0.453
97th to 129th day	0.029	0.062	0.269

The nitrogen losses amounted to about 25-30% in 3 to 4 months. Their high value was due apparently to the initially low C/N ratio of about 14.

The nitrogen losses, in percent, were somewhat lower immediately after setting up of windrows, and somewhat higher than the percentage of dry-matter shrinkage later on. It may be concluded that the nitrogen content of dry matter increased somewhat at the beginning, dropping back to the initial value later on

On the other hand, in relation to the organic matter the nitrogen content increased considerably, because the nitrogen losses in percent were not so high as the organic organic-matter shrinkage in percent. This was reflected in a reduction of the C/N ratio from 13.7 to 11, 4 to 10.8.

Sewage-sludge compost, accordingly, shows a good C/N ratio nearly equal to that of huminic acids in chernozem. Portion of the nitrogen-containing substance was apparently used by microorganisms as a source of carbon, since the C/N ratio of sewage sludge was significantly lower than in other urban wastes and even stable manure. This is probably why nitrogen losses in sewage-sludge composting are higher than in composting of other communal refuse of higher C/N ratio.

Within a certain error limit, the amounts of ash, phosphoric acid and lime remained constant during composting.

During windrow composting, belly-worm eggs were killed in less than 24 hours in the zones heated to at least 55°C. Fly maggots could no longer be detected in the sewage sludge a few days after setting up the windrows. Flies were no longer attracted by sewage sludge after short-time composting. Results of research conducted by the Hygienic Institute of the Humboldt University showed that various pathogens in the sewage-sludge compost windrows lose their viability within a short time.

In comparative pot experiments, sewage-sludge compost showed a significant fertilizing effect on neutral soil, whereas the sewage sludge had no effect or even reduced the yield. On acid soil, both the sewage sludge and the sewage-sludge compost had only a feeble fertilizing effect. Addition of calcium carbonate or lignite ash improved the fertilizing effect of sewage-sludge compost on that soil, while that of sewage sludge remained unaffected.

Summary

1. Sewage sludge is to be considered a potential source of infection. Its utilization for fertilizing purposes is therefore to be rejected.
2. The writer has developed a method of composting undigested sewage sludge without admixtures. After due drying, the sewage sludge in the drying bed is ploughed, harrowed and rototilled. The sewage sludge processed in that manner is then set up in windrows and yields ripe compost after 4 months.
3. This procedure makes it possible to obtain hygienically safe compost of high fertilizing value.

Bibliography

1. Bohme, L. Mullverspulung am Wernsdorfer See (Refuse Drainage near Lake Wernsdorf). – Wasser-Wirtschaft-Technik, Vol. 5, pp. 194–196. 1955
2. Bohme, L. Kompostierung von Klarschlamm nach dem Verfahren der "Naturlichen Kompostierung" (Composting of Sewage Sludge According to the "Natural Composting" Procedure). – Die Deutsche Landwirtschaft, Vol. 8, pp. 615–616. 1957.
3. Bohme, L. Unkrautbekämpfung unter besonderer Berücksichtigung arbeitswirtschaftlicher Erwagungen (Weed Control, with Special Consideration of Labor Economy). – Mitschurin-Bewegung Schulungsbeilage, No. 4. 1957.
4. Bohme, L. Fragen der Kompostierung von nicht ausgefaultem Klärschlamm (Composting Problems of Undigested Sewage Sludge). – Dissertation, Berlin. 1961.
5. Bohme, L. Verhinderung von anaeroben Zonen in Kompostmieten durch StAM (Prevention of Anaerobic Zones in Compost Windrows by the Stagewise Setting-up Method (StAM)). – Informationsblatt der IAM No. 25. December 1965.
6. Gotaas, H. B. Composting. – World Health Organisation, Geneva. 1956.
7. Harmsen, H. Fakale Gemüsekopfdungung als gesundheitliche Gefahr der Verwurmung, der Ausbreitung gefährlicher Darmkrankheitserreger und der Verbreitung der Erreger der Kinderlähmung und der epidemishen Hepatitis (Vegetable-Head Fertilization with Excrements as Danger of Contamination with Parasite Worms, Spreading of Intestinal Disease Germs, Poliomyelitis and Infectious Hepatitis). – Münchner Medizinische Wochenschrift, Vol. 95, pp. 1301–1305, 1953.
8. Imhoff, K. and E. Müller. Die Heissvergärung von stichfestem Schlamm (Hot Fermentation of Spadable Sludge). – Gesundheits-Ingenieur, Vol. 63, p. 160. 1938.
9. Kalbe, J. Ueber die Einwirkung der natürlichen Kompostierung auf die Lebensfahigkeit von Spulwurmeiern (Effect of Natural Composting on the Viability of Belly-Worm Eggs). – Die Deutsche Landwirtschaft, Vol. 6, pp. 440–441. 1955.

10. Kalbe, J. and A. Borchert. Ueber die Widerstandsfahigkeit der Eier von Ascaris lumbricoides L. bei der naturlichen Kompostierung (Resistance of Eggs of Ascaris lumbricoides L. in Natural Composting). — Archiv fur experimentelle Veterinarmedizin IX, pp. 142 — 144. 1955.
11. Knoll, K. H. Beitrag zum Thema "Klärschlammproblem" (On the "Problem of Sewage Sludge"). — Informationsblatt der IAM No. 24, September 1965.
12. Kreuz, A. Hygienische Beurteilung der Abwasserverwertung (Hygienic Evaluation of Sewage Utilization). — Gesundheits-Ingenieur No. 76, pp. 106 — 211. 1955.
13. Reinhold, F. Weitere Erfahrungen zur Spulwurmplage (New Facts about the Belly-Worm Nuisance). — Bericht der Abwassertechnischen Vereinigung e. V., R. Oldenbourg Munchen, Issue 1, pp. 149 — 150. 1950
14. Rohde, G. Kompostierung des Schweinekotes (Composting of Pig Excrement). — Mitschurin-Bewegung, Vol. 4, pp. 1124 — 1130. 1955.
15. Rohde, G. Kompostierung von Schweinekot (Composting of Pig Excrement). — Mitschurin-Bewegung Vol. 5, pp. 1120 — 1125, 1956.
16. Rudat, K. D. Untersuchungen über den Nachweis der Wurmeier im Abwasser Berlins (Research on Identification of Worm Eggs in the Sewage of Berlin). — Zeitschrift für die gesamte Hygiene und ihre Grenzgebiete, Vol. 3, pp. 227 — 230, 1957
17. Schroeder, H. Zur Frage der Wurmeier im Abwasser Berlins (On the Problem of Worm Eggs in the Sewage of Berlin). — Gesundheits-Ingenieur, Vol. 70, pp. 410 — 415, 1949.
18. Schuphan, K. Beeinträchtigen Riesel- und Fäkaldüngung die Qualität, insbesondere den gesundheitlichen Wert von Gemüse und Obst? (Do Sewage Farming and Fecal Fertilization Affect the Quality, and in Particular, the Sanitary Value of Fruit and Vegetables? — Zentralblatt für den deutschen Erwerbsgartenbau, Vol. 3, p. 8, 1951.
19. Strauch, D. Veterinärhygienische Untersuchungen bei der Verwertung fester und flussiger Siedlungsabfälle (Veterinary-Hygienic Investigation of the Utilization of Solid and Liquid Urban Refuse). — Schriftenreihe aus dem Gebiet des öffentlichen Gesundheitswesens Georg Thieme Verlag Stuttgart 1964.
20. Strauch, D. and K. H. Knoll. Beitrag zum Thema "Klärschlammproblem" (On the "Problem of Sewage Sludge"). — Informationsblatt der IAM No. 24, September 1965.

A REPORT ON THREE MANURE COMPOSTING PLANTS

By John S. Wiley, Tennessee Valley Authority, Chattanooga, USA

Accumulations of poultry and animal manures may create nuisance and public health problems, including odors, dust and breeding places for flies and other vermin. Manure from diseased fowl or animals may contain pathogenic microorganisms and spread them to healthy birds or animals. Plant diseases may be spread similarly, since the manures may contain weed or other undersirable seeds found in the feed or bedding.

Fresh manure can be promptly spread and plowed or disced in, or they can be ground and mixed with water from thin spreading or application with irrigation water. These methods require year-round application, which is not always suitable for the crops commonly grown.

Manures may be decomposed either aerobically or anaerobically in liquid or solid form, either alone or with other organic wastes. They may be treated at sewage treatment plants after certain preliminary treatment (at the source) when discharge to the sewers is acceptable by the local sewerage authority. Manure slurries can be digested in tanks similar to sewage sludge digesters or in aerobic lagoons. Studies in progress at Washington State University indicate that water carried manures may be treated in short-detention anaerobic lagoons followed by aerobic lagoons. Other studies are being initiated by the University of California at Davis on the activated sludge treatment of various manures.

Manures, either with sufficient bedding or mixed with other dry wastes, or those with a low enough moisture content, can be simply piled in the open for storage and aerobic decomposition. This is a form of composting that frequently results in fly production or nuisances unless conditions are such that oxygen is present throughout the piles. In composting, the manure or manure mixture is turned to provide mixing and aeration, assuring control of odors, flies, weed seeds, and pathogens by maintaining aerobic conditions and permitting adequate heat development. This report is on three manure composting plants observed recently in Washington and California.

Sunrise Compost Company, Parker, Washington

Mr. Ted Williams operates a windrow composting plant that treats a mixture of feedlot manure from 5,500 steers and meat packing wastes, including blood. The windrows are about five feet high and contain approximately one ton of wastes per one and one-half feet of length. Windrows are turned six times during the six-week composting period, using a front-end loader and a large truck-mounted manure spreader. The loader used is a Caterpillar 933 Traxcavator with a one and one-half cubic yard bucket.

FIGURE 1. Windrow composting at Sunrise Compost Company, Parker, Washington. Blood from the slaughterhouse is being added to steer manure and paunch manure

In forming the windrows, Mr. Williams first makes a windrow by mixing steer manure and paunch manure from the packing plant. The steer manure has generally been stock-piled for about six weeks. A trough is made along the top of the windrow to receive blood from a tank truck (see Figure 1). The wastes are then put through the spreader which mixes them and forms new windrows. Mr. Williams reported only a minor fly problem with spraying required only once during 1963. All wastes except horns, ears, and tails are composted. These wastes are dumped into a pit and buried in a landfill.

The compost is then processed through the following equipment, which was homemade:

A 3/4-inch vibrating screen (tailings are mainly sticks and stones and are discarded).

A 3/16-inch rotary drum screen with interior angle-iron lifters.

A miller-type impact mill where material retained on the drum screen is ground.

A current, single-pass, rotary drum drier.

Part of the compost is stored in bulk and part is bagged. The compost is sold as "Wake-UP Soil Conditioner" and "Composted Steer Manure" mostly in the Seattle, Portland, and Spokane areas.

John Prohoroff Egg Ranch,
San Marcos, California

John Prohoroff has been composting chicken manure from his one million bird egg ranch for some time (see "Composting Controls Flies (and Saves Money) at Poultry Ranch"), Roland C. Hartmann, Pacific Poultrymen, February, 1963; reprinted in Compost Science Spring, Volume 4, No. 1, 1963.

FIGURE 2. One of the two rotary drum composters at Prohoroff's egg farm in San Marcos, California

On 18 February, 1964, Mr. Prohoroff had one rotary drum composter operating with a second unit available but not yet installed, and two additional drums purchased but not on the ranch (see Figure 2). Also under construction were a large windrow composting area and a compost bagging and storage house. In preliminary runs with the rotary drum, it was learned that the moisture content of the chicken manure must be considerably lower than for composting other wastes; that is, in the range of 35 – 40% moisture. While the experimental unit was being charged at the smaller end, Mr. Prohoroff indicated that the flow could be reversed. Air was provided by means of a blower located at the discharge end of the drum.

Chicken manure, without bedding or other carbonaceous matter, is not only of poor structure for aerobic composting but is so rich in nitrogen that appreciable amounts of nitrogen are lost as ammonia during the composting process. Mr. Prohoroff reported that the compost, after several days in the drum, had a nitrogen content of about four percent (dry basis). A pronounced ammonia odor was evident in the compost, indicating that nitrogen continues to be lost in the windrow curing of the compost. It appears that, if carbonaceous wastes (such as, sawdust, hay, rice hulls, cotton gin trash) were added at about 1:1 with chicken manure, the moisture and NH_3-loss problems would be minimized.

Julius Goldman's Egg City, Moorpark, California

This egg ranch with one million layers has a Eweson Rotary Drum Composter which is under test composting straight chicken manure (see Figure 3). Mr. E. L. Waterman, California Eweson Corporation, Santa Barbara, California, stated that the drum is ten feet in diameter by 100 feet long. If the unit proves successful in the field trials, a total of six drums will be provided at three locations to treat all the manure from the ranch. Each drum holds about 150 tons, is divided into three compartments, and has a retention time of six days. Air is blown into the discharge end of the drum. Mr. Waterman indicated that there had been some trouble with "mud-ball" formation at moisture contents of 38 – 42%. This is a somewhat lower moisture content than used at the San Marcos installation. As of 25 February, 1964, nosatisfactory runs had yet been made in the rotary drum unit. Again, the need for dry, low-nitrogen wastes to mix with the chicken manure is evident. The inclusion of such wastes would improve structure and aeration within the mass, permit operation at a higher moisture content, and reduce nitrogen losses during the process. The compost is to be sold under the name "Organagro" as a humus plant food. A compost processing bagging and storage building is under construction.

FIGURE 3. The Eweson composting drum at Egg City, Moorpark, California, is 10 feet in diameter by 100 feet long

These three plants are interesting attempts to process manures in a sanitary manner and to utilize the resulting product for the benefit of the soil.

ANNOUNCEMENTS OF THE SECRETARIAT

The International Organization for Urban Sanitation (INTAPUC) will hold its

9. International Congress
on 26 – 30 June 1967, in Paris

As in previous congresses, urban hygienists and experts will convene from all over the world to consider problems of urban sanitation ranging from refuse collection to processing or completely eliminating refuse.

The congress deals with important, permanently topical problems, e.g., disposal of refuse, its utilization in agriculture, and its incineration.

The congress is supplemented by an exhibition of machinery and equipment used for refuse collection and processing, extending from simple trash cans to models of incineration plants. Experts will have the opportunity of gathering information on the most recent achievements in the field of urban sanitation.

The official languages of the congress are German, French, and English.

Following a request made in December 1963 by the Paris City Council, the French national organization of INTAPUC has undertaken the planning and organizing of this international event. It is hoped to make it a complete success, and everything will be done to achieve this end.

Enquiries and bookings should be addressed to the congress office,
A. G. H. T. M., 9, rue de Phalsbourg, Paris XVII^{e}, France.

COMMUNICATIONS FROM INDUSTRY

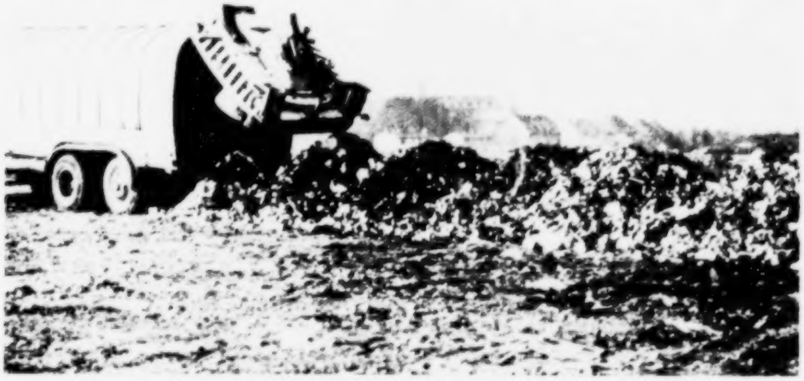
KUKA-Compacted Refuse

What is the meaning of the term "KUKA-compacted refuse?"

This refuse is so called because its state is in fact compact as shown in the photograph only after it is discharged from a KUKA refuse vehicle. The refuse is comminuted, well mixed, and permanently compacted. It would be carrying coals to Newcastle to discuss the advantages of comminuted refuse.

Intensive mixing and permanent compaction are very important in all refuse-disposal methods, as they lead to a reduction in costs.

How is it possible? After it is filled the conveyer wheel carries the refuse into the container which rotates continuously during the charging process. A screw conveyer then moves the refuse continuously on, turning it over for 1.5 to 3 hours, depending on the size of the refuse collection vehicle. Different kinds of waste (vegetable refuse, packaging materials, ash, bottles) are mixed intensively although they were charged at different times. Voluminous refuse (e.g., paper) is comminuted by the heavier constituents and simultaneously moistened by the less dry kinds. This mixing and moistening also ensures permanent compaction. The shape assumed in the collection vehicle is retained without volume increase when this homogeneous refuse is discharged. In addition, depending on the kind of refuse, compaction up to 1:4 is obtained by means of the screw conveyer during final compression at the rear cover.



The director of a well-known German engineering office says, "I cannot use refuse from KUKA vehicles for analyses (composition, moisture content, screening samples, etc). Mixing, moistening and volume reduction have changed its initial state to such an extent that no proper analysis is possible".

Since only KUKA refuse vehicles deliver refuse in the form described, we have chosen the term "KUKA-compacted refuse".

We shall now consider its advantages for refuse-disposal methods employed today.

Controlled Tipping

KUKA-compacted refuse ensures proper and economical tipping. The permanently compacted refuse requires hardly any additional compaction by means of bulldozers. After it has been shoved aside, the area is immediately free for the next refuse vehicle. With suitable organization, the refuse dump is thus further compacted by the refuse vehicles.

Tests in a city in the German Federal Republic have shown that refuse from KUKA refuse vehicles has a bulk weight of 1,000 kg/m^3 one year after tipping. At the initial value of 250 kg/m^3, this implies a volume reduction to 25%. The question may be asked whether high investments for other methods of refuse disposal are justified since, e.g., in the case of incineration, approximately 15% (by volume) of the refuse has to be removed and tipped afterward.

So-called dump fires are comparatively rare at the waste consistency obtained, as incandescent ash residues are quenched during the continuous turning in the refuse vehicle. Similarly, a KUKA refuse vehicle on fire is a rarity, in contrast to vehicles in which the refuse is at rest in the container.

It is also rare to find the well-known vermin nests, as the homogens, as waste, contain hardly any voids.

Refuse Composting

One is tempted to talk of "predigestion" when one sees refuse discharged from a KUKA refuse vehicle. This expression certainly is technically incorrect, but the idea is suggestive. In any case, KUKA-compacted refuse provides the best preconditions for further processing during composting. Rapid digestion of homogenized refuse reduces the work in turning over, as compared with refuse deposited in layers. Permanent compaction is important also from the viewpoint of the area taken up by a composting plant. The space required for discharged refuse not permanently compacted is 1.5 to 2 times that of the container volume. With KUKA-compacted refuse, 1 m^3 container volume equals 1 m^3 discharged refuse. Shorter turning periods and reduced space requirements lead to considerable cost reduction.

Refuse Incineration

According to statistical data, refuse delivered for incineration may have a calorific value ranging from 800 to more than 2,000 cal/kg. A single charge, if the refuse is delivered in a vehicle in which the container stores contents without mixing and in the order of collection, may include these different calorific values.

The control of incineration is much simpler and design of grates and combustion chambers is much easier if the differences in calorific value are small. This is reflected in construction costs and in plant reliability.

KUKA-compacted refuse helps reduce considerably the range of variation of calorific value.

The advantage of reduced hopper capacity should not be overlooked. As in composting, the space required for KUKA-compacted refuse is less. The cost involved in increasing the hopper capacity of an incineration plant by 50 or 100% is great.

These considerations make it clear that handling refuse with KUKA refuse vehicles offers many advantages in addition to efficient transportation, and that they lead to considerable reduction in costs.

LITERATURE RECEIVED BY THE SECRETARIAT

Albinus, G. Probleme und Moglichkeiten der Müllverbrennung in kleineren Oefen (Problems and Possibilities of Refuse Incineration in Small Incinerators). – Stadtehygiene, Issue 4. 1966.

Amt der Steiermärkischen Landesregierung Graz. Vortragsreihe Abfallverarbeitung, 18.11.1965, Berichte der wasserwirtschaftlichen Rahmenplanung, Vol. 6, Graz, 1966

Andres, O. Und wenn der ganze Mull verbrennt – die Schlacke bleibt uns doch (Even if All Refuse is Burnt – Clinker Remains). – Stadtehygiene, Issue 2. 1966

Angenend, F.-J. Die Nass-Luft-Oxydation von Schlamm (Moist-Air Oxidation of Sludge). – Brennstoff-Wärme-Kraft, VDI Düsseldorf, Vol. 18, No. 5. 1966.

Banse, H. J. and D. Strauch. The Importance of Pre-Fermentation in Composting. – Compost Science, Autumn-Winter, Vol. 6, No. 3, 1966.

Böhme, L. Temperaturmessungen in Kompostmieten (Temperature Measurement in Compost Windrows). – Die örtliche Versorgungswirtschaft, Institut für Kommunalwirtschaft, Dresden, 2nd year of publ., Issue 2. 1966.

Bohme, L. Stufen-Ansetz-Methode verhindert anaerobe Zonen (Graded Setting-up Method Prevents Formation of Anaerobic Zones). – Die örtliche Versorgungswirtschaft, Institut für Kommunalwirtschaft, Dresden, 2nd year of publ., Issue 2. 1966.

Bollinger, O. E. Varianten des Belebtschlammverfahrens (Variants of Activated Sludge Treatment). – Städtereinigung, Wien I, 2nd year of publ., Nos. 2, 3 and 4, 1965.

Bopp, R. Müllverbrennung–die Entwicklungsarbeit einer Spezialfirma (Refuse Incineration-Development Work of a Specialized Firm). – Schweiz. Handelszeitung, 24 March 1966, No. 12. 1966

Brodbeck, J. Die Skorstens-Müllverbrennungsanlage (The Skorstens Refuse-Incineration Plant). – Vortragsreihe Abfallverarbeitung, 18.11.1965, Berichte der wasserwirtschaftlichen Rahmenplanung, Vol. 6, Graz. 1966.

Davies, A. G. Leatherhead, England Plant Makes and Sells Compost. – Compost Science, Autumn-Winter, Vol. 6, No. 3. 1966

Digby, J. B. Müllabfuhr mit maximaler Nutzlast im Londoner Stadtteil Hammersmith (Refuse Collection at Maximum Net Load in Hammersmith, London). – Städtehygiene, Issue 4. 1966.

Erbel, A. Zur Beseitigung sperriger Abfälle (On the Disposal of Bulky Waste). – Kommunalwirtschaft, Düsseldorf, No. 1. 1966.

Erbel, A. Die Lösung der Mullbeseitigungsfrage in der Südpfalz (Solution of the Refuse Disposal Problem in the Southern Palatinate). – Kommunalwirtschaft, Düsseldorf, No. 1. 1966.

Erhard, H. Gedanken über den Müll-Ferntransport (Thoughts on Long-Distance Transportation of Refuse). – Stadtetag, Issue 5. 1966.

Farkasdi, G. Die mikrobiologischen Vorgänge bei der Kompostierung (Microbiologic Processes during Composting) – Organischer Landbau, 12th year of publ., Issue 4. 1966.

Martin, P. Plant Pathology Problems in Refuse Composting. – Compost Science, Autumn-Winter, Vol. 6, No. 3. 1966.

Maystre, Y. Must Bad Odors Always Accompany a Composting Plant? – Compost Science, Autumn-Winter, Vol. 6, No. 3. 1966.

Merkel, W. Städtereinigung in Japan. 2. und 3. Teil (Town Cleaning in Japan (Parts 2 and 3)). – Städtereinigung Issues 3 and 4, Wien I, 2nd year of publ. 1965.

Moegling, E., W. Heitmüller, and W. Drewes. Praxis der zentralen Klärschlammverbrennung am Beispiel Essen-Karnap (Centralized Sewage-Sludge Incineration as Practiced in Essen-Karnap). – Brennstoff-Wärme-Kraft, VDI Düsseldorf, Vol. 18, No. 5. 1966.

Niemitz, W. Der Heizwert von Klärschlamm und seine Beziehungen zu anderen Schlammkenndaten (The Calorific Value of Sewage Sludge, and Its Relationship to Other Sludge Characteristics). – Das Gas- und Wasserfach, Wasser/Abwasser, 106th year of publ., Issue 50. 1965.

Obrist, W. Additives and the Windrow Composting of Ground Household Refuse. – Compost Science, Autumn-Winter, Vol. 6, No. 3. 1966.

Orth, H. Reinigung von Benzinabscheidern und Beseitigung ausgelaufenen Oels (Cleaning Gasoline Separators and Removing Spilled Oil). – Der Stadtetag, Issue 4. 1966

Orth, H. Entfernungsabhängiger Kostenverlauf beim Mülltransport in Müllsammelwagen (Costs of Refuse Transportation in Refuse-Collection Vehicles as a Function of Distance). – Kommunalwirtschaft, Düsseldorf, Issue 1. 1966.

Palm, R. Zukünftige Entwicklung der Müllverfeuerungsanlagen (Future Development of Refuse-Incineration Plants). – Kommunalwirtschaft, Düsseldorf, Issue 1. 1966.

Palm, R. Besichtigungen von Müllverfeuerungs-Anlagen (Inspections of Refuse-Incineration Plants). – Kommunalwirtschaft, Düsseldorf, Issue 4. 1966.

Palm, R. Gedanken zur kombinierten Schlamm- und Müllverbrennung in Rostfeuerungen (Thoughts on Combined Sludge and Refuse Incineration on Grates). – Brennstoff-Warme-Kraft, VDI Düsseldorf, Vol. 18, No. 5. 1966.

Pelzer, P. La technique des lits fluidisés (Fluo Solids) en relation avec les problèmes derivant du traitement des eaux. – La Tribune du CEREDEAU, Liège, Belgique, Vol. 19, No. 267. 1966.

Perl, K. I rifiuti urbani e la loro eliminazione. – Rivista Tecnica della svizzera italiana, No. 1, 1966.

Perl, K. and C. Schirrmeister. Die Müllverbrennungsanlage der Stadt Bergamo (The Refuse-Incineration Plant of the Town of Bergamo). – Städtereinigung, Wien, 3rd year of publ., Issue 1. 1966.

Rasch, R. Möglichkeiten der Verbrennung von Industrieabfällen (Possibilities of Incinerating Industrial Waste). – Auszug Vortrag, 11.2.1966. Mülltechn. Kolloq. Stuttgart., Brennstoff-Wärme-Kraft, VDI Düsseldorf, Vol. 18, No. 5, 1966.

Rasworschegg, H. Gestaltung der Kessel-, Filter- und Transport-Anlagen bei der Abfallverbrennung (Design of Boiler, Filtration, and Conveyer Plants for Waste Incineration). – Vortragsreihe Abfallverarbeitung, 18.11.1965, Berichte der wasserwirtschaftlichen Rahmenplanung, Graz, Vol. 6. 1966.

Riad, A. Composting Activities in Cairo Egypt. – Compost Science, Autumn-Winter, Vol. 6, No. 3. 1966.

Rogge, W. Veraschung ölhaltiger Schlämme im Drehtrommelofen (Reducing Oily Sludge to Ash in Rotary Drum Incinerators). – Brennstoff-Wärme-Kraft, VDI Düsseldorf, Vol. 18, No. 5. 1966.

Frey, H. Das Schlammentwasserungsprojekt der Stadt Nurnberg (The Sludge-Desiccation Project of the City of Nuremberg). – Brennstoff-Wärme-Kraft, VDI Düsseldorf, Vol. 18, No. 5. 1966.

Fuller, W. H. New Organic Pelleted Compost. – Compost Science, Autumn-Winter, Vol. 6, No. 3. 1966.

Generlich, K. Veraschung von Abwasserschlamm im Drehetagen-Ofen (Ashing Sewage Sludge in Rotary Storey Furnace). – Brennstoff-Warme-Kraft, VDI Düsseldorf, Vol. 18, No. 5. 1966.

Giese, W. and **P. Schwarz**. Die Veraschung kohlenwasserstoffhaltiger Raffinerieschlämme (Ashing Refinery Sludge with Hydrocarbon Content). – Brennstoff-Wärme-Kraft, VDI Düsseldorf, Vol. 18, No. 5. 1966.

Gilbertson, W. E. and **R. J. Black**. A National Solid Waste Program is Created. – Compost Science, Autumn-Winter, Vol. 6, No. 3. 1966.

Hedoin, M. L'élimination des ordures ménagères des petites collectivités et des stations climatiques. – Techniques et Sciences Municipales, 61e année, Paris, No. 4, 1966.

Hindinger, L. Müllverbrennung in München (Refuse Incineration in Munich). – Der Städtetag, Issue 3. 1966.

Hirschheydt v., A. Wer ist kompetent? (Who is competent?). – Kommunalwirtschaft, Issue 3. 1966.

Hösel, G. Entwicklung und gegenwärtiger Stand der Bemühungen einer zentralen Regelung auf dem Gebiet der Abfallbeseitigung (Development and Present State of Attempts to Establish a Centralized Scheme for Waste Disposal). – Korrespondenz Abwasser, Bonn, No. 12. 1965.

Huber, G. L'usine d'incinération d'ordures de Zermatt. – Bulletin de l'Association Romande pour la protection des eaux et de l'air, ARPEA, No. 15, Genève. 1966.

Hutchinson, G. A. How the Year Finished at Auckland Compost Plant. – Compost Science, Autumn-Winter, Vol. 6, No. 3. 1966.

Katz, P. Probleme der Abfallbeseitigung der Region Basel (Problems of Waste Disposal in the Basle Region). – Schweiz. Bauzeitung, 83th year of publ., Issue 25 of 24. 6. 1965.

Kefford, J. F. Composting Trials with Pear Canning Wastes. – Compost Science, Autumn-Winter, Vol. 6, No. 3. 1966.

Kehr, D. and **P. Pflanz**. Die Kläranlage Nordhorn; eine Anlage mit aerober Schlammstabilisierung (The Nordhorn Purification Plant; a Plant with Aerobic Sludge Stabilization). – Das Gas- und Wasserfach, Wasser/Abwasser, 107th year of publ., Issue 10. 1966

Keller, E. F. Kehrichtbeseitigung aus der Perspektive einer Gemeinde (Trash Removal from a Community Viewpoint). – Plan, Schweiz. Zeitschr. für Landes-, Regional- und Ortsplanung, 22nd year of publ., No. 3. 1965.

Kern, A. Der neueste Stand der Müll- und Industrieabfallverbrennung mit und ohne Energieerzeugung (Latest Developments in Incinerating Refuse and Industrial Waste with and without Power Production). – Vortragsrethe Abfallverarbeitung, 18. 11. 1965, Berichte der wasserwirtschaftlichen Rahmenplanung, Graz, Vol. 6. 1966.

Kuchta, H.-D. Veraschungsanlage für ölhaltige Schlämme und Rechengut nach dem Drehrohrofenprinzip (Plant Using the Rotary Tubular Kiln Principle for Ashing Sludge and Screenings). – Brennstoff-Wärme-Kraft, VDI Düsseldorf, Vol. 18, No. 5. 1966.

Malchereck, W. Erfahrungen mit Kunststoff-Müllgefässen (Experiences with Plastic Refuse Containers). – Städtehygiene, Issue 2. 1966.

Rose, G. Probleme der Müllbeseitigung: Glas im Müll (Problems of Refuse Disposal: Glass in the Refuse). — Wasser, Luft und Betrieb, Krausskopf Verlag, Mainz, 20th year of publ., No. 1. 1966.

Scholz, S. Müllschlacke als Wegbaustoff (Refuse Clinker as Road-Construction Material). — Der Stadtetag, Issue 3. 1966.

Schönbeck, F. Der 3. Internationale Kongress der Arbeitsgemeinschaft für Müllforschung IAM (The 3rd International Congress of the Refuse Research Organization (IRGRD)). — Vortragsreihe Abfallverarbeitung, 18.11.1965, Berichte der wasserwirtschaftlichen Rahmenplanung, Graz, Vol. 6. 1966.

Sontheimer, H. Moderne Verfahren zur Abwasserreinigung unter besonderer Berücksichtigung des Abfallproblems (Modern Methods of Sewage Purification, with Particular Attention Being Paid to the Waste Problem). — Vortragsreihe Abfallverarbeitung, 18.11.1965, Berichte der wasserwirtschaftlichen Rahmenplanung, Graz, Vol. 6, 1966.

Spinola, R. Die Planung von Abfallverarbeitungsanlagen (Planning of Waste-Processing Plants). — Vortragsreihe Abfallverarbeitung, 18.11.1965, Berichte der wasserwirtschaftlichen Rahmenplanung, Graz, Vol. 6, 1966.

Spohn, E. and D. **Knöfel**. Glas, Mineralien und Steine im Kompost (Glass, Minerals, and Stones in Compost). — Städtehygiene, Issue 2. 1966.

Stein, J. Ueber 3-jährige Versuche zur Schlammentwässerung mittels Precoatfilter auf der Kläranlage Weidenau-Geisweid (On Three Year Trials of Sludge Desiccation by Means of Precoat Filter in the Weidenau-Geisweid Purification Plant). — Das Gas- und Wasserfach, Wasser/Abwasser, 106th year of publ., Issue 50, 1965.

Steinbeisser, A. Ein Jahr Müllverbrennung in Rosenheim (One Year of Refuse Incineration in Rosenheim). — Der Städtetag, Issue 4. 1966.

Strauch, D. Zur Hygiene der Kompostierung von Siedlungsabfällen (On the Hygiene of Composting Municipal Waste). — Abwassertechnik, Udo Pfriemer Verlag, München 15, Series 1. 1966.

Ströhl, G. W. Ueber einen Fall weitreichender Grundwasserverunreinigung durch Pestizide und Detergentien (On a Case of Extensive Groundwater Pollution by Pesticides and Detergents). — Gesundheits-Ingenieur, Issue 4. 1966.

Stundl, K. Die Unterbringung von unbehandelten und behandelten Abfällen im Gelände (Disposal of Untreated and Treated Waste in the Countryside). — Vortragsreihe Abfallverarbeitung, 18.11.1965, Berichte der wasserwirtschaftlichen Rahmenplanung, Graz, No. 6. 1966.

Teensman, B. Development of Municipal Composting in the Netherlands. — Compost Science, Autumn-Winter, Vol. 6, No. 3. 1966

Tope, O. Sammlung, Abfuhr und Beseitigung von Hausmüll, Gewerbemüll und Schlacke (Collection, Removal, and Disposal of Household and Industrial Waste and Clinker). — Städtereinigung, Wien I, 2nd year of publ., Issue 3. 1965

Tope, O. Sammlung, Abfuhr und Beseitigung von Hausmüll, Gewerbemüll und Schlacke (Collection, Removal, and Disposal of Household and Industrial Waste and Clinker). — Städtereinigung, Wien I, 3rd year of publ., Nos. 1 and 4, 1966.

Tronko, W. Die Gefährdung des Grundwassers durch Abfälle (Danger to Groundwater through Waste). — Vortragsreihe Abfallverarbeitung, 18.11.1965, Berichte der wasserwirtschaftlichen Rahmenplanung, Graz, Vol. 6, 1966.

Vater, W. Die Schlammveraschungsanlage im Hauptklärwerk Stuttgart-Mühlhausen (Ashing Sludge in the Stuttgart-Mühlhausen Main Purification Plant). — Brennstoff-Wärme-Kraft, VDI Düsseldorf, Vol. 18, No. 5, 1966.

Watson, L. The Advance of Composting as a Refuse Disposal System. — Compost Science, Autumn-Winter, Vol. 6, No. 3. 1966.

Weiand, H. and K. Kalmbach. Die Anlage der Stadt Lausanne zur Verbrennung von Abwasserschlamm nach dem Wirbelschichtverfahren (City of Lausanne Plant for Burning Sewage Sludge According to Vortex-Layer Process). — Brennstoff-Wärme-Kraft, VDI Düsseldorf, Vol. 18, No. 5. 1966.

Wille, R. Ueber eine neue Art der Müllzerkleinerung (On a New Method of Refuse Comminution). — Kommunalwirtschaft, Düsseldorf, Issue 1. 1966.

Wotschke, J. Zur Entwicklung des einschmelzenden Verbrennens von Abfällen (On Developing Fusing Incineration of Waste). — Vortragsreihe Abfallverarbeitung, 18. 11. 1965, Berichte der wasserwirtschaftlichen Rahmenplanung, Graz, Vol. 6. 1966.

Wuhrmann, K. Zum gegenwärtigen Stand der Beseitigung von Oelabfällen (The Present State of Disposing of Oily Waste). — Schweiz. Bauzeitung, of 28 April 1966, 84th year of publ., No. 17. 1966.

Wuhrmann, K. Kompostieren oder verbrennen? (Composting or Incineration?). — Kommunalwirtschaft, Düsseldorf, Issue 1. 1966.

Wylemann, E. H. Totale Beseitigung fester und flüssiger Abfälle (Complete Disposal of Solid and Liquid Waste). — Plan, Schweiz, Zeitschrift für Landes-, Regional- und Ortsplanung, 22nd year of publ., Issue 3. 1965.

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FACTORS IN THE MATURING PROCESS OF SOME SWISS REFUSE COMPOSTS

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Introduction

The problem of suitable processing and utilization of urban waste, besides its hygienic aspect, is of major importance to the economy. It is well known that urban wastes, such as household garbage, street sweepings, market refuse and sewage sludge from municipal sewage purification plants contain, apart from carbohydrates – especially cellulose – relatively small quantities of organically bound nitrogen. Although composting of urban refuse is an age-old procedure, it is only in recent decades that various methods for the processing of refuse together with sewage sludge (as digested sludge) have come into use. The main purpose of the various modern composting plants using vastly different procedures is to obtain in the course of physicochemical and biological conversion a hygienically safe product with a high content of organic matter.

The available literature is very extensive. In addition to classical general reports on the actual composting of organic substances (Pfeiffer 1957; Glathe 1959, 1961; Smyk 1961; Straub 1961; Teensma 1962), there are also reports on comprehensive examinations. Hygienic problems in composting were treated by Knoll (1959, 1963), Strauch (1961), Wetzel (1961) and Parráková (1962), while Glathe et al. (1961), Farkasdi (1961) and Ahrens et al. (1965) dealt mainly with the microbiology of the composting process. Von Klopotek (1962) made extensive and valuable studies of isolated molds in the composting of urban refuse (in the starting material, after turning, at higher temperatures, as well as after lengthy composting and in finished composts). The question of sewage sludge as well as problems in the chemical analysis of refuse and composts in Switzerland were studied mainly by Braun (1965), Oršanić (1966) and Rollé (1964).

Authors of papers published so far deal mostly with the fermentation process itself, which they attempted to characterize. Few studies exist, however, of the constitution and the properties of mature refuse composts and refuse-sewage-sludge composts. It is the aim of the present work to find and examine methods of analysis suitable for determining the grade of maturity, by means of a comparative study of a number of Swiss composts (Table 1) produced by different processes. The following tests were carried out:

A. Microbiological Tests:

1. Determination of the number of microorganisms, bacteria, actinomyces, and fungi (mesophilic and thermophilic) [total plate count]
2. Determination of the coli titer
3. Qualitative evaluation
4. Chaetomium test for the determination of degree of fermentation.

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B. **Physicochemical Tests:**

5. pH value
6. Water content
7. Loss on ignition
8. Decomposable organic matter (DOM)
9. Resistant organic matter (ROM)
10. Carbon content of DOM
11. Amount of nitrogen (Kjeldahl method)
12. C:N ratio
13. Qualitative and quantitative determination of amino acids.

C. **Biological Tests:**

14. Plant test (with lettuce).

TABLE 1. Refuse and compost samples tested

Sample No.	Source of sample	EAWAG* No.	Addition (or not) of sewage sludge	Age (months)	Method of processing
1	Küsnacht (Zurich)	KT A 1 - 12	+	fresh	Refuse was crushed in hammer mills, homogenized in a Dano-Egsetor (holes Φ 1,5 cm) and sieved
2	Kusnacht (Zurich)	KT B 14	+	7	Processed as No 1 above, then fermented in 1-m high test windrows, twice turned
3	Küsnacht (Zurich)	KT D 19	−	7	As No. 2
4	Kusnacht (Zurich)	1068	+	14	Crushed in hammer mills, homogenized and sieved (1.5 cm) in Dano-Egsetor, composted in 2-m high windrows, twice turned
5	Hinwil (Zurich)	1066	+	8	Homogenization and prefermentation in Dano-Biostabilizer (3−4 days), crushing in hammer mill, sieving through a vibrator (Φ 5 cm) composting in windrows of 2−3 m height, turned once or twice
6	Hinwil (Zurich)	1065	+	11	As No. 5
7	Olten (Solothurn)	922	−	8	As No. 5
8	Buchs (St Gall)	888	+	7	Crushing in hammer mills, passing through a vibrating sieve (Φ 5 cm), composting in 2-m high windrows, turned once or twice

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*[Eidg. Anstalt f. Wasserversorgung, Abwasserreinigung u. Gewässerschutz.]

METHOD

A. Microbiological Tests

A quantity of 50 g refuse compost (dried at 25°C to constant weight) and 450 ml saline solution were shaken together for one hour. This suspension was further diluted in the usual manner. Determination of the number of microorganisms, i.e., bacteria, actinomyces and fungi, was performed by the membrane filter method. (Membrane filter K 5-Gottingen, flow rate 10 ml).

Cultures were inoculated into nutrient media, as follows:

Total of Bacteria:

23.0 g Difco bacto-nutrient agar
2.0 g $Na_2HPO_4 \cdot 2H_2O$ (according to Sorensen)
2.0 g NaCl
1.0 g Difco yeast extract
5.0 g glucose
1000 ml aqua dest.

Incubation period: 48 hr at 25°C for mesophilic, 55°C for thermophilic bacteria.

Actinomyces:

10.0 g glucose
0.50 g asparagine
0.50 g K_2HPO_4
20.0 g agar
1000 ml aqua dest.

Incubation period: 4 – 5 days at 25°C for mesophilic, and 48°C for thermophilic actinomyces.

Fungi:

1.0 g KH_2PO_4
0.50 g $MgSO_4 \cdot 7H_2O$
5.0 g malt extract
4.0 g Difco yeast extract
20.0 g agar
1000 ml aqua dest.

Incubation period: 3 days at 25°C for mesophilic, and 48°C for thermophilic fungi.

To the nutrient media for actinomyces and fungi 0.50 g terramycin (per 1 l nutrient) was added just prior to their introduction into Petri dishes.

For quantitative evaluation, the colonies on the membrane filter were counted.

For determination of the coli titer, compost diluted with Kessler-Swenarton medium (nutrient: gall, gentian violet, peptone, lactose and Durham tubes) was pipetted into test tubes and incubated for 48 hr at 37°C. If the nutrient solution became cloudy at the end of this period, and gases had formed, this diluted solution was inoculated on endo-agar and after 24 hrs of incubation at 36°C, examined for Escherichia coli. The qualitative evaluation of a culture is attained by using differential nutrient media. These colonies were separated from the membrane filter and pure cultures grown for the usual differentiation procedures.

Determination of the degree of fermentation was carried out by growth test of the fungus Chaetomium gracile Udagawa, according to Obrist (1965). (Principle: on an agar nutrient containing finely ground refuse or refuse compost, the growth and the formation of fruiting bodies of a Chaetomium gracile species (EAWAG No. 31) are measured).

B. Physicochemical Examinations

The physicochemical examinations (tests 5 to 12), were performed according to the methods of the IRGRI (1966 – Collection of Methods for the Examination of Refuse and Refuse Composts).

Qualitative and quantitative determinations of amino acids after hydrolysis of proteins: the acid hydrolysis of the substances to be analyzed was performed by the following method: 1 g of a powdered sample was reflaxed for 24 hr with 100 ml 6N salicylic acid. The hydrolizate was evaporated to dryness *in vacuo* at about 50°C, then absorbed in about 30 ml H_2O. 0.5 N NaOH was added to obtain a pH value of 2.5, and the volume was made up to 50 ml. After determination of the nitrogen content by the Kjeldahl method, the solution is ready for analysis. The qualitative and quantitative analyses of the fresh refuse (sample 1) and the mature compost (sample 2) was carried out by means of a Beckman analyzer for amino acids. In addition, all 8 samples were subjected to paper chromatographic qualitative examination.

Method of paper chromatography:
Solvent: N-butanol : glacial acetic acid : water (4 : 1 : 1 v. v.)

All the chromatographic investigations* were carried out on Whatman Paper No. 1, from 20°C by the descending method. Spray medium: ninhydrin spray for amino acids (Linskens, 1959).

C. Biological Examination with Lettuce (Lactuca satica var. capitata) as Plant Test (Teensma, 1964)

Peat mull in three beakers (400 ml each) was mixed thoroughly with 400 ml test compost and 600 – 800 ml tap water. The mixture was poured into plastic dishes ("Multitopf") in which 10 – 12-day old seedlings of lettuce, having two leaves each, were planted. Five parallel plants were planted of each sample, and one control (the latter with peat mull only, without compost). Those plants that remained upright and strong after 3 – 5 days at about 22°C under day-light lamps (Philips HPL 250 W) were considered to constitute positive results.

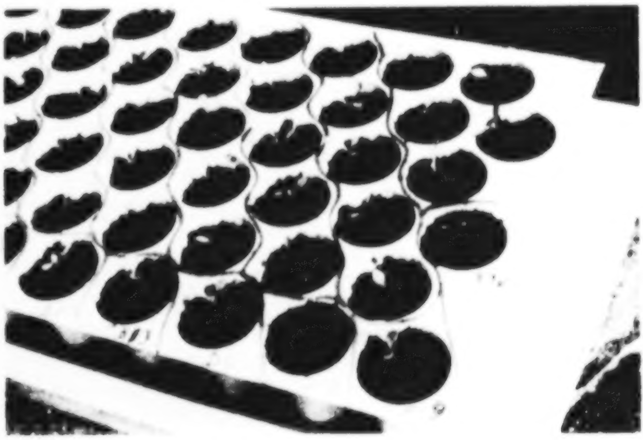

FIGURE 1. Plant test with Lettuce (Lactuca saliva var. capitata)

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* [Error in German text.]

DISCUSSION OF THE RESULTS

A. Results of the Microbiological Examinations

The counts of germinated bacteria, actinomyces and fungi are compiled in Table 2.

TABLE 2. Results of microbiological examinations (number of germs in millions per gram dry matter)

Material	Bacteria:		Actinomyces:		Fungi:		Coli titer:	Chaetomium test	Plant test
	mesophil. 25°C	thermophil. 55°C	mesophil. 25°C	thermophil. 48°C	mesophil. 25°C	thermophil. 48°C			
1. Tuffenwies KT A 1-12	102.800	4,850	1.820	0.189	20.700	1.660	10^{-4}	2,500	+
2. Tuffenwies KT B 14	26.500	10.530	0.030	0.137	0.109	0.113	10^{-1}	720	+
3. Tuffenwies KT D 19	18.170	5.933	0.038	0.108	0.048	0.055	$>10^{-1}$	800	+
4. Kusnacht MKK 1068	109.000	8.600	0.081	0.350	0.290	0.088	$>10^{-1}$	12	+
5. Hinwil 1066	30.000	3,840	0.001	0.009	0.001	0.004	$>10^{-1}$	4	+
6. Hinwil 1065	36.200	13,750	0,002	0,028	0.005	0,012	$>10^{-1}$	0	+
7. Olten 922	12.750	3,700	0,001	0,014	0.026	0,010	$>10^{-1}$	up to 400	+
8. Buchs 888	19.700	3,900	–	0,008	0,016	0.004	$>10^{-1}$	560	+

The examinations have shown the mesophilic bacteria in mature composts to amount to 12.7 – 36.2 mill germs/gram, compared to 102.8 mill/g in fresh refuse (sample 1). Only in sample 4 (Küsnacht MKK 1068, 14 months old) was the amount of mesophilic bacteria higher, i.e., 109.0 mill/g. For thermophilic bacteria the count varied between 3.7 and 13.7 mill/g in mature composts, compared to 4.8 mill/g in fresh refuse.

It was found that in contrast to the fresh refuse, where the count of mesophilic actinomyces was 10 times higher than that of the thermophilic ones (1,820,000 mesophilic as against 189,000 thermophilic), mature compost after 7 – 14 months yielded an amount of thermophilic bacteria far in excess of the mesophilic ones. It would seem that in the course of decomposition, thermophilic actinomyces proliferate markedly and this genus of microorganisms, though poor in species, is not without importance for the degradation of organic matter in the process of composting.

TABLE 3.

Microflora of the refuse composts examined

Bacteria	Tuffenwies			Kusnacht	Hinwil		Olten	Buchs
	KT A 1-12	KT B 14	KT D 19	MKK 1068	1066	1065	922	888
	1	2	3	4	5	6	7	8
Diplococcus sp.	+	+						+
Micrococcus sp.	+	+					+	
M. roseus	+			+				+
Sarcina sp.	+	+	+	+	+	+	+	+
S. lutea	+	+	+	+	+	+	+	+
Staph. albus	+	+	+	+	+	+	+	+
Staph. aureus	+							
Str. faecalis	+							+
A. aerogenes	+	+		+				+
Chromobacterium prodigiosum								+
Bacterium sp. I	+	+	+	+	+	+		
Bacterium sp. II	+	+	+	+	+	+	+	+
Bact. violaceum							+	
E. coli	+	+						
Proteus vulgaris	+	+		+	+			+
Pseudomonas sp.	+	+		+		+		+
Bac. brevis	+	+	+	+	+	+	+	+
Bac. cereus	+	+	+	+	+	+	+	+
Bac. megaterium	+	+	+	+	+	+	+	+
Bacillus sp. I		+	+	+	+	+	+	+
Bacillus sp. II		+	+	+	+	+	+	+
Bac. subtilis	+	+	+	+	+	+	+	+
Clostridium sp.				+			+	+
Corynebacterium sp.				+				
Undetermined genera	4	3	2	4	2	2	2	3
Aktinomyzeten :								
Actinomyces sp.	+			+				
Streptomyces sp. I	+	+	+				+	
Streptomyces sp. II	+	+	+	+	+	+		
Streptomyces sp. III (therm.)		+	+	+		+		+
Streptomyces sp. IV (therm.)	+	+	+	+	+	+	+	+
Fungi								
Absidia sp.							+	
Actinomucor sp.							+	
Asp. clavatus Desm.				+	+	+		
Asp. fumigatus Fres.	+	+	+	+	+	+	+	+
Aspergillus sp. I		+	+	+-	+	+	+	
Aspergillus sp. II			+		+	+		
Aspergillus sp. III		+	+		+	+	+	
Botrytis sp.		+	+					
Cephalosporium sp. I		+	+	+				
Cephalosporium sp. II			+	+				
Cladosporium sp.	+		+		+			+
Fusarium sp. I		+	+					
Fusarium sp. II					+	+		
Geotrichum candidum Link	+							
Gliocladium sp.		+	+					
Humicola sp.		+	+	+	+	+	+	+
Mucor pusillus Lindt	+	+	+	+	+	+	+	+
Mucor varians Povah	+			+				
Mucor sp. I	+	+	+		+	+		+
Mucor sp. II	+	+	+		+	+	+	+
Mucor sp. III		+	+	+			+	
Nigrospora sp.								+
Penicillium digitatum Sacc.	+	+	+	+			+	
Penicillium sp. I	+	+		+			+	+
Penicillium sp. II		+	+	+	+	+		
Penicillium sp. III		+	+	+	+	+	+	+
Rhizopus nigricans Ehrenb.	+	+			+			
Rhizopus sp.	+	+	+				+	+
Rhodotorula						+		
Scopulariopsis sp.		+	+-			+		

(cont.)

Bacteria	Tüffenwies			Kusnacht	Hinwil		Olten	Bucns
	KT A 1-12	KT B 14	KT D 19	MKK 1068	1066	1065	922	888
	1	2	3	4	5	6	7	8
Thermoidium sulfureum Miehe		+	+	+	+	+	+	+
Trichurus terrophilus		+		+	+	+	+	
Trichoderma lignorum		+	+			+		+
Trichothecium roseum Link		+	+	+		+	+	
Torula sp.		+	+					
Verticillium sp.	+	+	+					
Undetermined genera	4	3	4	3	2	3	3	2

The amount of fungi – mesophilic as well as thermophilic – shows great scatter. Nevertheless, all analysis of mature composts reveals very low values compared to fresh refuse (mesophilic: 1,400 – 290,000 germs/g as against 20.7 mill/g in fresh refuse; thermophilic: 4,200 – 113,000 germs/g in mature composts as against 1.6 mill/g in fresh refuse).

Although mature composts contain greater numbers of actinomyces or fungi, it is not clear whether these are due to proliferation or to secondary infection (Glathe, 1961). It should be noted, however, that the amount of microorganisms was determined by the membrane filter method, which does not lend itself to direct comparison with other methods, such as those of Koch, or Strugger (fluorescence-microscopic method). The composition of the nutrient medium also affects the amount of microorganisms to some extent.

The coli titer. There exists to-date no universal standard test for hygienic quality (as, for instance, the coli titer in drinking water). Determination of the coli titer could, therefore, be of some importance, especially with regard to composts used in horticulture. According to Parráková (1962), who for several years carried out hygienic controls, the coli titer in hygienically safe composts should amount to no more than 10^{-2} (0.01). In the author's own tests of mature composts, the coli titer is $>10^{-1}$ (sample No. $2=10^{-1}$), in contrast to fresh refuse, where 10^{-4} was counted. For this reason determination of coli titer is not carried out by means of the membrane filter method, since the first dilutions leave a thick deposit on the filter.

Qualitative evaluation. The qualitative evaluation of isolated microflora (without regard to the frequency of the isolated species) is shown in Table 3.

While in fresh refuse the species isolated belong to the typical normal microflora of vegetable waste, food remnants, sewage sludge and other refuse, during maturing of and in the ripened compost there appear sporogenes and thermophilic genera. The other isolated species, belonging to the normal air-, soil- and sewage microflora, found their way into the compost via secondary infection. In only a few instances were specific species isolated, e. g., Chromobacterioum prodigiosum in material from Buchs, Absidia sp. and Actinomucor from Olten, Rhodotorula from Hinwil. The remaining species were common to samples from nearly all composting plants. It seems likely that some bacteria, possibly actinomyces, can serve as means for determining compost quality, similarly to the fungi isolations from refuse compost after v. Klopotek (1962).

Chaetomium test for determination of degree of fermentation. The results of this test are shown in Table 2. According to present experience, on attaining a Chaetomium value of up to 500, refuse compost may be considered well matured.

In windrow composting, as customary with Swiss compost plants (windrow height: 1.5 – 2.5 m), this value is attained after 7 to 8 months during which the rows are turned twice (samples 4 – 7, Table 2). If the value is between 500 and 1,000, caution is recommended, especially with sensitive vegetables and potted plants (samples 2, 3 and 8).

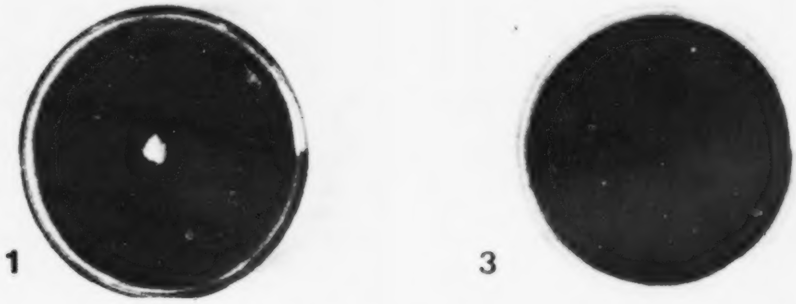

FIGURE 2. Chaetomium test: cultures after 5 days incubation
No. 1 – fresh refuse, sample 1; No. 3 – mature compost, sample 8.

B. Results of the Physicochemical Examinations

The results of physicochemical examinations are compiled in Table 4.

TABLE 4. Results of the physicochemical tests

Material	pH value	Water content %	Loss on ignition %	Decomposable organic matter (DOM)	Resistant organic matter (ROM)	C in DOM	N according to Kjeldahl	C/N
1. Tuffenwies KT A 1-12	7,0	54.0	64.7	57,4	7,3	25.7	0,88	29.3
2. Tuffenwies KT B 14	7,1	60.8	44.0	37.7	6,3	18.0	1,05	17,2
3. Tuffenwies KT D 19	7,4	63.1	47.9	35.7	12,2	16,4	1,03	16,0
4. Küsnacht MKK 1068	7,1	65.8	49.2	44,6	4.6	20,5	1,05	19.9
5. Hinwil 1066	7,3	52.7	36,4	29.2	7,2	13,4	0,83	16,2
6. Hinwil 1065	7.4	49.1	33,1	22.2	10,9	10,2	0,71	14,4
7. Olten 922	7.2	54.1	36.0	25.8	10,2	11,9	0,60	19,8
8. Buchs 888	7,6	45.4	31.0	20.1	10,9	9.6	0,75	12,9

The pH value

If the compost is not too young, the pH value is a good quality indicator as shown by Teensma (1962) in tests with Dutch composts. With satisfactory compost, the pH is about 7.0. According to this author noxious compost generally has a weakly acid reaction, i.e., pH 6.0 – 6.5. If, however, the compost is insufficiently fermented and contains butyric acid, the reaction is strongly acid, with a pH below 5.0 (Teensma, 1962). In the author's own tests, all the compost samples showed pH values of 7.1 to 7.6, while fresh refuse had a pH of 7.0. These figures indicate that the composts examined had satisfactory pH values.

Water content

The water content of the raw material plays an important part throughout processing (Farkasdi, 1961). In ripe composts it is derived mainly from atmospheric precipitations. In the author's own tests with mature composts conducted during winter and spring in varying weather the water content of ripe compost vaccilated to a considerable extent, i.e., between 45.4 and 65.8%.

Loss on ignition, decomposable organic matter, resistant organic matter and carbon in decomposable organic matter

Since these values relate to the entire organic substance, they vary with the composition of the initial material. The duration of the composting process is also of some importance (Niese, 1961). The values of the loss on ignition vaccilated between 31.0% and 49.2% in maturing composts (in fresh refuse – 64.7%), while the values of the DOM varied between 20.1% and 44.6% in ripe composts (57.4% in fresh refuse). These values are similar to those obtained by Obrist (1965) for refuse composts from various Swiss plants. The values for resistant organic substance (ROM), e.g., rubber, polyvinylchloride, polyethylene, are calculated from the difference between the values for loss on ignition and DOM. In the author's own tests it varies between 4.6% and 12.2%. The values of "C in DOM" vary accordingly.

Nitrogen content

As a rule, initial material derived from urban refuse has a nitrogen content of up to 1%; however, in particularly favorable conditions, values as high as 2.5% to 3.0% were found (Pfeiffer, 1957). In finished composts, too, the N-content varies. Pfeiffer (1957) found that in the course of proper conversion, the nitrogen content rose considerably, especially in the case of low values of the initial material. The author's own tests show similar values (samples 2, 3 and 4 – taken from the same plant). The other samples, however, reveal N-contents of 0.60% to 0.83%.

C:N ratio

The carbon/nitrogen ratio is essential for the fermentation process itself as well as for the evaluation of the finished compost. Together with other factors it can also serve as indicator of the composting conditions and of the maturity degree of the compost. If the C/N ratio varies over a relatively wide range (in which case the composting process may take place at a slowed-down rate) it is possible to narrow the range by addition of nitrogen-rich material, such as sewage sludge. A C/N ratio of <20 for mature compost would seem to be optimal. Such a ratio was found in all the samples investigated.

Determination of amino acids

TABLE 5 Composition of the amino acids in samples 1 and 2

Amino acids	Sample 1 KT A 1 - 12	Sample 2 KT B 14
	Amino acids as percentage of refuse-dry matter	
Acid and neutral components:		
Aspartic acid	0,403	0,409
Threonine	0,203	0,211
Serine	0,202	0,189
Glutamic acid	0,661	0,568
Proline	0,257	0,223
Glycine	0,273	0,310
Alanine	0,263	0,292
Cystine	probably traces	
Valine	0,225	0,243
Methionine	0,062	present, but indeterminable
Isoleucine	0,176	0,180
Leucine	0,301	0,307
Tyrosine	0,096	0,093
Phenylalanine	0,164	0,187
Levulinic acid	probably present	
Basic components:		
Lysine	0,197	0,168
Histidine	0,082	0,070
Arginine	0,208	0,210
Ammonia	0,116	0,151

In the course of fermentation, albumin is hydrolyzed to amino acids which, in turn, are decomposed to ammonia. According to investigations by Sauerlandt (1965), the amino acid contents greatly decrease in the first ten days of aerobic fermentation. In order to obtain some insight into the composition of amino acids in mature composts, a paper chromatographic method for determining amino acids was devised and applied to 7 samples of mature compost and one sample of fresh refuse.

The following amino acids were found paper chromatographically:

Leucine
Glycine
Alanine
Glutamic acid
Methionine
Histidine
Isoleucine
Aspartic acid
Threonine
Serine
Proline
Lysine
Valine
Arginine

Tests with 8 different compost samples yielded the same results.

C. Biological Examination

The plant tests with lettuce yielded positive results throughout. This proved that the refuse composts had matured and could be used for plant growing.

Fresh refuse was an exception, while still giving positive results, because here the decomposition process has not yet set in. With the start of fermentation, results become negative.

FIGURE 3. Plant test – positive result.

Summary

In examining the factors of the maturing process in several Swiss refuse composts produced by different processes, comparative microbiological, physicochemical and biological tests were made.

Determination of the number of microorganisms was carried out by the membrane filter method, which is very suitable for this purpose. Microbiological results showed that the microflora of the mature composts contained, apart from mesophilic bacteria, also numerous thermophilic genera of bacteria, actinomyces and fungi. In regard to the hygienic state, the coli titer (in test tubes with nutrient composed of gall, gentian violet, peptone and endo-agar) proved to be a sensitive indicator. For the determination of the fermentation grade, the Chaetomium-test proved particularly advantageous for Swiss composts, which contain relatively little ash; beside determination of the coli titer and some typical species of the microflora, this test may also facilitate qualitative evaluation.

Among the physicochemical tests, determination of the pH value and C/N ratio are particularly significant. It may be assumed that the microbiological tests described, together with the pH value, C/N ratio and lettuce plant test most probably are decisive in the determination of the maturation degree of Swiss composts. Whether the values obtained are also applicable to the composts of other countries, cannot yet be ascertained on the basis of the present studies.

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Bibliography

Ahrens, E., G. Farkasdi and J. Ibrahim. Einige Kriterien zur Charakterisierung der Mullrotte (Some Criteria for the Characterization of Refuse Fermentation). – IRGDR Information Bull., Vol. 24, No. 17, 1965.

Braun, R. Der heutige Stand der Klärschlammbeseitigung (Present State of Sewage Sludge Removal). – Verbands-Bericht No. 87/1 of the Verb. Schweiz. Abwasserfachleute. 1965.

Farkasdi, G. Untersuchungen über die bei der Kompostierung auftretenden Temperaturen sowie den Gehalt der Stapelluft an Kohlendioxyd und Sauerstoff (Investigations of the Temperatures Occurring during Composting, and Content of Carbon Dioxide and Oxygen in the Pile-air). – AkA, DLG-Verlag, Frankfurt/M. 1961.

Farkasdi, G. Beitrage zur Mikrobiologie der Kompostierung (Contributions to the Microbiology of Composting). – IRGDR Information Bull., Vol. 13, No. 5. 1961.

Glathe, H. Biologische Vorgange bei der Kompostierung von Müll (Biological Processes in Refuse Composting). – Intern. Congress for Removal and Utilization of Urban Refuse, Scheveningen Intern. Agricult. Centre, Wageningen, Netherlands. 1959.

Glathe, H. Ueber die Mikrobiologie des Kompostierungsvorganges (On the Microbiology of the Composting Process). – AkA, DLG-Verlag, Frankfurt/M. 1961.

I. A. M. Methodik. Methodensammlung zur Untersuchung von Mull und Mullkompost (Collection of Methods for the Examination of Refuse and Refuse Compost). – Secretariat of the IRGDR, Zurich (in Press). 1966.

Klopotek, A. v. Ueber das Vorkommen und Verhalten von Schimmelpilzen bei der Kompostierung stadtischer Abfallstoffe (On the Occurrence and Behavior of Molds during Composting of Urban Waste). – A. v. Leeuwenhoek, Vol. 28, No. 141. 1962.

Knoll, K. H. Die Kompostierung im Blickpunkt der Hygiene (The Hygienic Aspect of Composting). – Intern. Congress for Removal and Utilization of Urban Refuse, Scheveningen Intern. Agricult. Centre, Wageningen, Netherlands. 1959.

Knoll, K. H. Die Einflüsse verschiedener Kompostierungsverfahren auf nicht sporenbildende pathogene Bakterien (Effects of Various Composting Processes on Nonsporogenous Pathogens). – IRGDR Information Bull., Vol. 19, No. 3. 1963.

Linskens, H. F. Papierchromatographie in der Botanik (Paper Chromatography in Botany). – Springer-Verlag, Berlin, Gottingen, Heidelberg. 1959.

Niese, G. Versuche zur Selbsterhitzungsfahigkeit von Mull-Faulschlamm-Gemischen (Experiments with Self-heating Capacity of Refuse and Digested-Sludge Mixtures). – AkA, DLG-Verlag, Frankfurt/M. 1961.

Obrist, W. Enzym-Aktivitat und Stoffabbau im rottenden Mull; Vorschlag fur eine neue mikrobiologische Methode zur Bestimmung des Rottegrades (Enzyme Activity and Degradation in Decomposing Refuse; a New Microbiological Method is Suggested for the Determination of Degree of Fermentation). – IRGDR Information Bull., Vol. 24, No. 29. 1965.

Oršanić, B. Methode zur Bestimmung des Kohlenstoffes der abbaubaren organischen Substanzen in der Müllschlacke (Method for Determination of Carbon in Decomposable Organic Substances of Refuse Clinker). – IRGDR Information Bull., Vol. 26, No. 5. 1966.

Parráková, E. Hygienische Kriterien für die Beurteilung der Abfallkomposte (Hygienic Criteria in the Evaluation of Refuse Composts). – IAM Informationsblatt, Vol. 16, No. 9. 1962.

Pfeiffer, E. Anleitung fur die Kompostfabrikation aus stadtischen und industriellen Abfallen (Guide for the Production of Compost from Urban and Industrial Refuse). – Verl. G. Fischer, Stuttgart. 1957

Rollé, G. and B. Oršanić. Eine neue Methode zur Bestimmung der abbaubaren und resistenten organischen Substanz in Mull und Mullkomposten (A New Method for Determination of Decomposable and Resistant Organic Substance in Refuse and Refuse Composts). – IAM Informationsblatt, Vol. 21, No. 3. 1964.

Sauerlandt, W. Aminosauren in technisch und biologish-technisch aufbereiteten Mullkomposten (Amino Acids in Technically and Biologically Processed Refuse Composts). – IRGDR Information Bull., Vol. 24, No. 24. 1965.

Smyk, B. Współczesny stan badan nad przerobem nieczystości miejskich na drodze biotermicznej. – 1st Scientific-Technical Conference: "Postep techniczny w dziedzinie oczyszozania miast" Wisła, 3-5 March 1961, organized by: Polskie Zrzeszenie Inzynierów i Techników Sanitarnych Oddział w Katowicach przy współudziale Instytutu Komunalnej, Slaski Ośrodek Doświadczalny w Katowicach. 1961.

Straub, H. Untersuchungen des Einflusses technischer Bedingungen bei der Verrottung von Siedlungsabfallen unter den Voraussetzungen des Werkbetriebes (Investigation of the Effects of Technical Conditions Prevailing during Fermentation of Domestic Refuse within Production Conditions of the Plant). – AkA, DLG-Verlag, Frankfurt/M. 1961.

Strauch, D. Veterinärhygienische Untersuchungen bei der Verwertung von stadtischem Müll allein und in Verbindung mit Abwasserrückständen (Veterinary-Hygienic Examinations in Utilization of Refuse Alone and Refuse in Combination with Sewage Residues). – AkA, DLG-Verlag, Frankfurt/M. 1961.

Teensma, B. Neue Richtlinien für die Kompostierung von zerkleinertem Frischmüll in den Niederlanden (New Guidelines for the Composting of Crushed Fresh Refuse in the Netherlands). – IAM Informationsblatt, Vol. 16, No. 5. 1962.

Teensma, B. Stichting "Compost" Afdeling Landbouwzaken Verslag van de proefnemingen over het jaar. 1962.

Wetzel, R. Veterinarparasitologische Untersuchungen bei der Kompostierung von Mull-Faulschlamm-Gemischen (Veterinary-Parasitological Studies in Composting of Refuse and Digested Sewage-Sludge Mixtures). – AkA, DLG-Verlag, Frankfurt/M. 1961.

APPLICATION OF RAPID METHODS FOR EXAMINING THE FERMENTATION PROCESS IN REFUSE-SEWAGE SLUDGE COMPOSTS

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Source of Composts: Bad Kreuznach — Dano Process

Composting process:

The compost consists of 85% domestic refuse and 15% digested sludge on an average. After magnetic removal of metals and mechanical discarding of other large objects the raw material is placed in a special Dano-drum for crushing, heating and mixing, without prior storage. Prefermentation sets in while the refuse passes through the drum. The raw compost thus formed is set up for further composting. The windrows are located in the vicinity of the plant and are about 3 m wide, 2 m high, and 100 m long. They are not aerated; their disinfection proceeds biologically.

I. Sampling and Pretreatment of Samples

The first sampling was intended for general examination by classical methods and for preliminary evaluation of the rapid tests. The samples were taken from center windrows of different ages. Duration of storage in windrows was 1 to 16 months. At the second sampling, for detailed examination of the rapid tests, samples were taken from 3 layers of each windrow. The windrows were 1, 6, 12 and 18 months old. Comparisons were made with fresh compost from the Dano-drum.

All the samples for general examination were carefully mixed, dried at 105°C and ground to a fine powder in an IkA mill. The samples intended for examination by the rapid methods were left in the fresh state in polyethylene bags.

II. General Examination (Specification of Method)

For the general characterization of the composts, we determined:

1. Moisture content and dry matter. Initial weight: 20 g fresh substance (Fr. S.); drying at 105°C.
2. pH value, electrometrically, by means of a quinhydrone electrode, with compost in a 0.1 N KCl solution, in a proportion of 1:2.5.
3. Loss on ignition (ash content) at 800°C. Initial weight: 10 g dry matter (D. M.).
4. Total humus was determined by the dichromate method. Initial weight: 1 g D. M.
5. Soluble humus in NaOH extract. Initial weight: 1 g D. M.
   One gram D. M. was dissolved in 10 ml 1 N HCl with 25 ml H_2O added and brought to boiling centrifuged and washed until it was free of chloride. The residue was dissolved in 15 ml 1 N NaOH and 50 ml H_2O, brought to boiling and simmered for 45 min, then centrifuged. The residue was dried at 105°C. The dichromate method was applied with the following variation:

   2 N K_2CrO7 — instead of 25 ml, we took 50 ml;
   Conc. H_2SO_4 — instead of 40 ml. we took 80 ml.

6. The total nitrogen content was determined by the Kjeldahl method. Initial weight: 1 g D. M.
7. The NH_4 and NO_3 nitrogens were determined in the K_2SO_4 extract. Initial weight: 20 g D. M.
8. $CaCO_3$ was determined by the Scheibler method.
9. Minerals were determined by incineration at 500°C. Initial weight: 1 g D. M.
10. Maximum moisture capacity
11. Weight per volume was determined by the cylinder method.

III Rapid Methods

For these methods we used the Geisenheimer water pincers (1)

1. Measurement of free water in the composts
The water pincers, with filter paper attached, were for 15 min inserted into the compost sample, after which the paper was taken off and the water absorbed weighed.

2. Determination of the NH_4 and NO_3 nitrogens in the soil solution
The water pincers, to which two dry, weighed filter papers had been attached, was for 15 min inserted into the fresh compost sample, then the dirty rim of the paper was cut off and the water absorbed weighed. One paper served for the determination of NH_4, the other for that of HO_3.

a). **NH_4 determination**: The weighed paper was transferred to a test tube and allowed to react for 15 min with 5 ml 1% acetic acid. Then the solution was siphoned off into a second test tube by means of a water jet aspirator, and 1 ml 0.17 N NaOH, 1 ml 50% potassium sodium tartrate and 0.5 ml Nessler's reagent added.
The colors of the solutions were compared with a calibration scale treated in the same manner (0; 5; 12.5; 25; 50; 100 μg N/5 ml). The values obtained were converted to 1 ml soils solution.

b). **NO_3 determination**: The weighed absorbent paper was transferred to a test tube and reacted with 5 ml of 1% acetic acid. This solution was siphoned off over a fritted glass filter, with zinc dust serving as a reducing agent. The reduced solution was treated with 1 ml 1:10 "E solution" (a mixture of α-naphthylamine and p-nitraniline (Z. anal. Chem., 151, 259, 1956)). The colors formed were compared with the calibration scale made of solutions treated in the same way (0; 5; 12.5; 25; 50; 100 μg N/5 ml) and the values obtained calculated for 1 ml soil solution.

3. Measurements of free electrons by means of indicators (redox measurement)

Electrometric measurement of the pH values was found to be unsuitable for determination of the redox potential in soil solutions, because that method is not sufficiently sensitive to reveal the finer differences. We, therefore, used the indicator method which exhibits an extraordinarily high degree of sensivity, enabling us to observe redox changes small as $5 \cdot 10^{-5}$ mg-equiv. It is important that the measurements of oxidation and those of reduction equivalents be clearly distinquished. For oxidation measurements one starts from a colorless reduced solution L_0; oxidation produces violet color, expressed in terms of (+) values. For measurement of the reduction values one starts with L_4, which is an oxidized, violet solution that is discolored by reducing agents, the discoloration grades being expressed in terms of (-) values. All color shades can be colorimetrically observed and calculated from the differences between the oxidation calibration curve and the reduction calibration curve readings.

The values so obtained are expressed in nanogram-equiv. (= 10^{-6} mg-equiv) from which the value for 1 ml soil solution is calculated.

The values so obtained are expressed in nanogram-equiv (= 10^{-6} mg-equiv) from which the value for 1 ml soil solution is calculated.

Measurement procedure. The water pincers with 2 dry, weighed filter papers were submerged in the compost long enough for the papers to become soaked. The absorbed water was weighed. One paper was immersed in 10 ml L_4 solution, the other in 10 ml L_0 solution. After 15 min. the colors were measured by the colorimeter, the extinctions in terms of mg-equiv were read from the calibration curves and calculated for 1 ml soil solution.

4. Plant seedling test for harmful materials in the soil

The compost was mixed with quartz sand in proportion of 1:3; 200 ml of the mixture were filled into Neubauer dishes and wetted to 70% of its mximum moisture capacity, then 50 grams of rye were laid out. Growth and root formation were continuously observed. After 17 days the fresh and dry weights of the surface parts were determined.

IV. General Examinations

We studied 15 compost samples, aged as follows:

No. 1: fresh
No. 2: 1 month
No. 3: 3 months
No. 4: 4 months
No. 5: 5 months
No. 6: 6 months
No. 7: 7 months
No. 8: 8 months
No. 10: 10 months
No. 11: 12 months
No. 12: 16 months

The average values obtained by the 15 tests are shown in Table 1. Variation ranges are given in brackets.

The general examination thus revealed that the refuse-sewage sludge was of very good quality. All values were optimal; the variation ranges, however, were rather wide, nowithstanding careful sampling. This is due to the nonuniformity of the substrate.

The carrying out of these tests called for a skilled worker (a graduate chemist or chemical technician) and a well-equipped laboratory. The expenditure for the general examination was not justified by the results, since the values failed to show any correlation to the aging process of the windrows or to the fermentation process.

V. Evaluation of Rapid Methods

When the rapid checks were made directly on the spot, no satisfactory results could be obtained. The distribution of moisture as well as nitrogen was not uniform, so that the measured values varied over too wide a range. Better results were obtained with average samples. These were taken from 3 layers, going from the outside towards the inside of the windrow.

Layer (a): 0 – 10 cm; layer (b): 40 – 50 cm; layer (c): 1 m (windrow core)

Age of Piles	
No. 1	1 month
No. 2	6 months
No. 3	12 months
No. 4	18 months

TABLE 1.

	a) in the fresh substance, %	b) in dry matter, %	c)* in 100 ml fresh substance, g
Moisture content	40. 0 (28. 1-51. 2)	-	17. 0 (12. 3-22. 3)
Dry matter	61. 0 (50. 5-72. 0)	-	26. 0 (16. 1-36. 9)
Loss on ignition	24. 0 (20. 5-27. 1)	39. 5 (28. 7-52. 8)	16. 1 (11. 5-21. 0)
Ash	35. 1 (22. 2-50. 8)	60. 0 (47. 2-70. 7)	25. 4 (18. 9-39. 9)
Total humus	9. 9 (4. 6-11. 6)	14. 8 (7. 5-19. 5)	6. 1 (4. 0-8. 8)
Alkali-soluble humus	4. 2 (1. 7-7. 6)	7. 1 (2. 9-12. 7)	3. 0 (0. 9-5. 3)
Total N	0. 8 (0. 5-1. 0)	1. 4 (1. 1-1. 7)	0. 5 (0. 4-0. 9)
C/N ratio	7. 1	7. 1	7. 1
$CaCO_3$	3. 7 (2. 1-6. 6)	6. 2 (4. 0-9. 2)	2. 6 (1. 2-4. 3)
K_2O	0. 4 (0. 2-0. 5)	0. 7 (0. -0. 8)	0. 3 (0. 1-0. 3)
Na_2O	0. 2 (0. 1-0. 3)	0. 3 (0. 2-0. 5)	0. 1 (0. 1-0. 2)
CaO	2. 4 (1. 6-3. 3)	4. 0 (2. 4-5. 5)	1. 8 (1. 0-3. 2)
Mg	0. 3 (0. 1-0. 3)	0. 5 (0. 2-0. 6)	0. 2 (0. 1-0. 5)
P_2O_5	0. 4 (0. 3-0. 5)	0. 7 (0. 5-0. 8)	0. 3 (0. 1-0. 5)
pH value		7. 8 (7. 3-8. 1)	

* Values given under (c) are decisive.

TABLE 2.

Windrow and layer	Moisture content		Free water, mg · cm^{-2} m^{-1}	Redox, nanogram equiv/1 ml soil solution	NH_4-Nμg/ml soil solution	NO_3-Nμg/ml soil solution	K_2SO_4 N-content mg/100 ml fresh substance	
	weight %	vol. %					NH_4	NO_3
Fresh	37,7	13,6	24	0	42	41	16,1	2,1
No. 1 (a)	41,1	18,3	64	6	31	613	13,8	7,5
No. 1 (b)	24,6	14,5	0,45	-11,270	89	262	28,2	4,9
No. 1 (c)	31,1	10,6	10	- 5,670	65	39	14,8	1,2
No. 2 (a)	46,6	15,8	56	+ 1,270	14	322	13,3	9,0
No. 2 (b)	36,6	15,1	22	- 1,060	17	1,119	15.9	31.0
No. 2 (c)	40.7	27,6	18	- 5,550	69	600	26.2	7.6
No. 3 (a)	42.3	14.4	49	+ 1,480	40	685	9.5	22.0
No. 3 (b)	43.6	18.7	70	+ 1,119	59	383	15.6	13.2
No. 3 (c)	39.4	17.3	0.67	- 2,770	700	566	28.5	7. 4
No. 4 (a)	36.6	17.7	76	+ 1,750	71	283	17.6	6.8
No. 4 (b)	27.2	12.9	2.8	+ 8,000	52	1,041	17.4	40.0
No. 4 (c)	34.9	17.8	3.5	+ 4,200	96	1,923	18.6	59.9

The advantage of the rapid methods is that they can be used simply and quickly by any trained laboratory assistant and with a minimum of apparatus. The examinations can be carried out in the composting plant itself, facilitating constant observation of the fermentation process in the windrows. The results shown in Table 2 indicate a distinct trend of the age structure of the piles and their maturation grades, as seen from the values obtained for the redox measurements and for the released NO_3 amount. The measurements obtained for the amount of free water were indicative of a very uneven water distribution in the windrows. Next to very moist layers were very dry ones, in which fermentation proceeded only slowly or not at all, owing to lack of moisture.

The trend of the NO_3 values revealed that as the windrows aged, the NO_3 values increased. Young windrows contained more NO_3 in their water layers than in their cores; in older rows, the opposite applied. This is due to the fact that oxidation starts in the outer layer and gradually spreads inwardly; besides, precipitations wash the NO_3 into the lower layers.

Determination of the values for NO_3 in K_2SO_4 extract — which was performed alongside the rapid test — showed, with few exceptions, good agreement with the NO_3 measurements obtained by the water pincer method. Here, too, the NO_3 values increased with the age of the piles.

The NH_4 values, on the other hand, whether obtained by the water pincer or by the K_2SO_4 extract method, failed to indicate any clearly defined trend.

The most significant values were obtained for the redox measurements. These indicated how oxidation proceeds from the outer layers and gradually spreads inward; only the ohdest windrow gave (+) values also for its core samples.

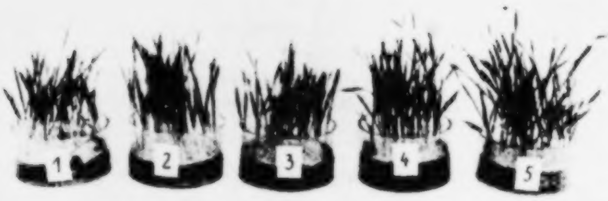
Seedling test for harmful materials in the soil

These tests were made in order to establish whether the composts contained harmful materials. It was found that fresh and 1-month old compost caused slight growth suppression and browning of the roots. Table 3 shows fresh and dry weights of above-ground parts of rye seedlings and the nitrogen release of the substrates.

TABLE 3.

Windrow and layer	Fresh	1(a)	1(b)	1(c)	2(a)	2(b)	2(c)	3(a)	3(b)	3(c)	4(a)	4(b)	4 (c)
Fresh weight, g/dish	5.44	6.64	5.30	6.45	7.26	9.18	10.15	11.2	8.92	9.99	6.45	9.18	9.80
Dry weight, g/dish	0.59	0.71	0.64	0.70	0.66	0.93	0.98	1.17	0.87	0.96	0.72	0.94	1.24
N-release, μg per ml soil (NO_3+NH_4)	83	644	351	104	336	1,136	669	725	442	1,266	354	1,093	2,019

The physiological development of the rye seedlings showed no dependence on the N-release of the soil, because they derive their nitrogen in the first 17 days from their grain proteins, while the soil nitrogen — though taken up — affects their physiology only insignificantly in relation to their weight. However, seedlings cultivated in dishes with higher N-content, acquired a markedly darker color.



Plant test according to Neubauer:

1 – Fresh compost; 2 – 1-month old compost; 3 – 6-month old compost; 4 – 12-month old compost; 5 – 18-month old compost.

Steps to be Taken in Composting

1. **If measured values are too low**
   a) **Moisture.** If the moisture rim measures less than 2 mm, the compost should be washed. A quantity of mm water should be added equal to the height of the compost in cm (e.g., 150 cm height = 150 mm water). For this purpose the surface is leveled out, so that a trapezoidal cross section is obtained, and the water distributed over the upper trapezoid surface.
   b) **Nitrogen.** Values lower than 1 mg NO_3-nitrogen/ml soil solutions together with satisfactory redox and moisture levels indicate lack of nitrogen. In this case the sludge component should be increased.
   c) If the redox values are too low, the compost should be turned. Inadequate NO_3 values occur whenever a) and c) are not optimal.
2. **If the measured values are too high**
   a) A moisture rim wider than 25 mm indicates that the compost contains too much water and too little air. This can be corrected by a single turning, and loose piling.
   b) On finding over 20 mg N-NO_3 per 1 ml soil solution, the sludge component of the compost should be reduced.
   c) Excessive redox values are practically unknown.

Summary and Recommendation:

The classical methods of examining refuse compost are unsuitable for determination of the maturing process in compost windrows. Little can be inferred from their results, and their procedure is costly. More conclusive on the degree of maturation are the rapid methods.

Great importance attaches to the manner of sampling. The best results in our examinations were obtained with larger well mixed average samples, drawn from a particular compost layer. Samples for rapid tests, should be analyzed on withdrawal as speedily as possible in order to forestall their further decomposition under conditions differing from those prevailing in the windrow. Basically, it suffices to examine the NO_3 release and the redox values in the cover of the windrow; from there measurements, the fermentation progress can be inferred.

The water release of the composts may be determined either directly in the windrows, i.e., in several spots located at the same layer level, or in average samples. We recommended the following limiting values: the water release in 5 min should be not less than 15 mg H_2O (≈ 2 mm rim) and not more than 80 mg H_2O (≈ 25 mm rim). The NO_3 release increases in the core of the windrows with maturing compost; the degree of maturation can thus be established by the amount of NO_3 released. On completion of the fermentation, the NO_3 values were found to amount to between 1,000 and 2,000 μg NO_3 nitrogen for 1 ml soil solution. This is equivalent to grade Ia of direct coloring in the paper (N-tester).

The redox measurement evinced a definite correlation to age and layer depth of the windrows. In young composts the values lay within the (-) range; with aging, the values progressing from the outer to the inner zones of the windrows shifted to the (+) range. Therefore, when (+) values are manifest in core samples, it can be inferred that the fermentation process is complete.

Our examinations thus lead to the conclusion that simple rapid methods, which lend themselves to speedy application in every composting plant, provide a reliable means for determining the degree of maturation of refuse composts.

Acknowledgement. This work was carried out with the financial support of the Federal Ministry of Health, whose assistance we acknowledge with profound gratitude.

Bibliography

Tepe, W. and E. Leidenfrost. Ein Messverfahren zur Bestimmung der Wasserversorgung der Pflanzen (A Measuring Procedure for Determining the Water Supply of Plants). — Z. f. Acker- u. Pflanzenbau, Vol. 115, Issue 3, pp. 223—230. 1962; Vol. 117, Issue 4, pp. 395—402. 1963.

FURTHER MARKETING OUTLETS FOR REFUSE COMPOST

By H. Guldenmann, Head of the Office for Water Economy
of the Canton Basle-District (Basel Landschaft), Liestal

Information Bulletin No. 26 of April 1966 carried an article by von Hirschheydt describing the prospects for marketing compost in Switzerland as none too bright. Without going into the question of the extent to which the author's calculations hold good, it must certainly be admitted that inasmuch as the profitable sale of refuse compost is concerned, for use in parks, orchards, vegetable gardens and vineyards as well as agriculture and forestry, there is little ground for optimism.

In connection with the preparations for the establishment of the refuse processing plant in Füllinsdorf (Composting by the Buehler-Dano system with incineration of tailings and bulky materials), which was decided upon in January 1966, by the cantonal Parliament of Basle-District, our office too had to consider whether and where the compost could be marketed. A survey revealed that the canton Basle-District contained parks, orchards, vegetable gardens, vineyards and farm and forest lands totaling about 6,230 ha. According to data by Keller, this area could utilize, theoretically, about 150,000 m^3 compost annually, with regular compost manuring. The author recommends, however, that in actual fact only 10% of this figure, i.e., about 15,000 m^3 per annum, be taken into consideration. Since compost production of the Füllinsdorf plant will presumably reach only about 10,000 m^3 initially, and about 15,000 m^3 after 10 to 15 years, we need not have been concerned about the setting up of this plant.

Notwithstanding the favorable inferences from the above data, we chose to take a more pessimistic view — albeit only as regards the marketing of the compost — and went about exploring further possibilities for the use of the compost. By coincidence, we had at that time just completed a so-called "refuse register," listing and card-indexing all public and private refuse dumps located in the canton's territory, irrespective of whether they were still in use or had been abandoned. This work was done with a view to obtaining a survey of the manner of refuse disposal to date and especially as planned by the local and regional authorities, i. e., precluding construction sites and determining locations of new waterworks and their protection zones.

These data also proved useful in deciding upon the measures that will have to be taken in regard to existing refuse dumps when the new composting plants in Basle and Füllinsdorf start operating (presumably in 1969). It is intended to abolish the present dumps, or local conditions permitting — viz. landscape and water supply protection, forestry, approach roads, etc. — to use them hence to only a limited extent (e.g., for depositing rubble and excavated material). To avoid overloading the new plant at the beginning it is planned to carry out the change in stages, starting with the closing of those dumps whose continued use seems most questionable from the point of view of water economy, etc.

Finally, the refuse register is also helpful in the planning of large regional dumps for deposition of rubble and excavation materials, as well as for incineration of residues from refuse processing plants or for industrial wastes which cannot be processed by these plants. Experience has shown that refuse dumps which are operated in the correct manner, i.e., precluding adverse effects on their surroundings and on water sources, require a not inconsiderable investment: they need good approach roads and earth removing equipment; supervision is necessary to ensure controlled tipping and fences are required to keep out undesirable tippings; finally, on exhausting their holding capacity, they must be cultivated and carefully made to blend with the surrounding landscape. In order to keep these costs — or the tipping dues levied to cover them — within reasonable limits, large tips are required that can be used many years, Our survey, therefore, focused on the selection of existing dumps that could be geared to long-range regional tipping; alternatively, it focused on the search for suitable new tipping sites.

The results of our investigations were most surprising. In the relatively small canton with an area of 427 km^2 and 74 communities totaling about 175,000 inhabitants, there exist over 400 public and private dumps with a total surface area of over 600,000 m^2. Only few of these refuse dumps are suitable for conversion into large regional tipping grounds. A great number of new dumps with an additional surface of of ca. 300,000 m^2 will have to be made available. Altogether the canton Basle-District will therefore have a tipping area of nearly one million m^2, which on exhausting its holding capacity, and in compliance with the regulations of the cantonal Forestry Office, will have to be covered with a cultivation-soil layer 80—100 cm deep and as rich in humus as possible.

Assuming an average of 50 cm humus, we shall require in the next decades a minimum of 500,000 m^3 of this material, which is one of the scarce commodities in our canton. The cantonal refuse processing plant in Füllinsdorf thus comes as a timely stopgap. With a compost-production capacity of $10-15{,}000$ m^3 the plant would be working to full capacity for many decades, producing compost for the reclamation of communal and regional refuse dumps alone, in the unlikely case that no compost whatever could be sold to vegetable growers and similar consumers.

The utilization of refuse compost for humus-topsoiling of refuse dumps is of interest also from the financial point of view, as compost produced to this end will require less extensive processing since especially where afforestation is concerned, it may be deposited unsieved and uncrushed. Regarding transport costs, we are at present studying the feasibility of reemploying the refuse collection trucks which normally return empty from the processing plant It is certain, however, that this manner of refuse disposal will in many cases be more expedient and possibly also cheaper than incineration, which, as is well known, still leaves a considerable amount of clinker to be deposited.

The above described manner of solving the compost disposal problem is applicable presumably not only in the canton Basle-District, but also in many other places, since there is everywhere an abundance of tipping grounds, which should eventually be sensibly blended with the landscape. The author therefore hopes that his lines will stimulate publication of similar solutions. A study should be made of all available ways and means for the solution of the refuse problem.

Bibliography

Von Hirschheydt, A. Ueber die Bestimmung der mutmasslichen Absatzaussichten fur Mull-Kompost als Voruntersuchungs-Massnahme (Determination of Sales Expectations for Refuse Compost as a Measure for Preliminary Investigation). — IAM Informationsblatt, No. 26, p. 23 ff.

Keller, P. Möglichkeiten des Komposteinsatzes im Pflanzenbau, Fortbildungskurs der EAWAG. 1964 (Possibilities for the Application of Compost in Plantations, Extension Course of EAWAG. 1964).

DISCUSSION

Contribution by Dipl. Ing. V. Stahlschmidt, Zurich, to Dipl. Landwirt A.v. Hirschheydt's article "Determination of Sales Expectations for Refuse Compost" which appeared in Information Bull. No.26

As a builder of composting plants, this contributor is likely to be biased. However, since the last page of the paper and the conclusions have often been used as an argument for the sale of incineration plants, a closer scrutiny of these conclusions is warranted.

1. Consumers

Agriculture is not taken into consideration, not even in respect of such special crops as field vegetables, sugar-beet, tobacco, etc. Considering that in

Switzerland about 58,000 ha are planted with potatoes, vegetables and tobacco, it is obvious that this could affect von Hirschheydt's statistics very considerably. It is true, of course, that farmers must make use of their own stable manure, but closer examination reveals that this manure is very unevenly distributed; that it cannot be readily transported over great distances and that in many regions it is not available in sufficient quantities to ensure optimum humus supply.

In explanation of his deliberate omission of agriculture as a potential consumer, von Hirschheydt argues: "We must not ignore the enormous decline in the purchase of compost by Dutch agriculture." The reference sources, which are equally accessible to von Hirschheydt, reveal a different picture (VAM Mitteilung, 21st year of publ., No. 1. 1966):

> "The use of refuse compost in agriculture has decreased in the last years. This is not the result of poorer achievements with compost fertilizing. The real cause is the greatly increased demand for more expensive types of compost for horticulture, which led the composting plants to concentrate on the more profitable production of these better qualities at the expense of the cheaper types of compost."

Nevertheless, according to the same service, out of a total of 160,000 tons of compost sold in 1965, 54,000 tons were used by Dutch agriculture. The total area of cultivated land in Holland is somewhat smaller than that of Switzerland.

2. Determination of Areas

In this respect von Hirschheydt's method is based on estimated values. This should be noted, because further on in the study precise values are used, so that the reliability of the data seems greater than it actually is.

3. Requirements

The values stated were all based on Dutch studies which do not consider the peculiarities of Swiss soils. However, in the absence of Dutch data, figures established in Switzerland were quoted for tree nurseries. Why the same was not done for viniculture remains inexplicable, since relevant Swiss data are available, whereas the Dutch can have no knowledge of the particular requirements of viniculture and of the climatic conditions prevailing in wine growing areas. If von Hirschheydt had availed himself of Swiss data in this field, his calculations would differ by several hundred tons. The inclusion or noninclusion of Liechtenstein would have made no great difference.

The above-mentioned source, with which von Hirschheydt is not unfamiliar, reports also on experiments carried out in the course of 13 years with sugar-beet fertilized with 30 tons of compost per 1 ha and compared to stable-manure fertilization. The sugar yield of the compost-fertilized plots was 20% higher. This may be of interest also to Swiss farmers.

The reduction factor for the calculation of the so-called settled demand was fixed by von Hirschheydt quite arbitrarily at 12%; it might be lower, but it might also be considerably higher. Sales in Holland, as shown by the above-cited source, are **not determined by the demand, but by the production.** There is thus no reason whatsoever for calculating a reduction factor. If Dutch conditions were to be taken as a guideline, settled demand might very well be assumed to exceed 200,000 tons. The comparison with Holland should not be overdone — but if it is right for one person (von Hirschheydt), it must also be fair for another.

4. Supply and Demand

The calculation of the 1968 compost yield in Switzerland is incorrect. Since data are available for the correct calculation of the refuse yield, and since the fermentation loss during compost maturation has been determined by EAWAG, the error is inexplicable. Production of refuse compost in 1968 will amount to ca. 60,000 tons/year, i.e., one third of the Dutch production.

The inclusion, by von Hirschheydt, of plants that have not yet been decided upon, and his omission of others more likely to be established, is merely indicative of the dubiousness of his entire examination.

5. Graphic Representation

This representation, which was probably to serve as a convenient illustration, is misleading, inasmuch as the sales territory of all the plants is indicated by an equally large circle, irrespective of whether the production of a plant amounts to 10,000 or to only 1,000 tons annually. Furthermore, the graph fails to reflect topographical differences.

Compost production is obviously concentrated on either side of the Zurich Lake, i.e., in the Horgen and Pfannenstiel plants, which will attain a full year's production only in 1968 — and in the Hinwil plant. Only this region will by 1968 reach an output large enough to justify the creation of a sales organization. Holland's compost sales are due entirely to such an organization. In Switzerland there are still countless potential compost consumers who have never heard of compost, even in the immediate neighborhood of composting plants. A compost quality suitable for horticulture is todate produced only on a very small scale.

6. Conclusions

Since von Hirschheydt's data concerning consumers, determination of areas, requirements and quantities produced, are wrong or very inaccurate, as shown above, his conclusions can only be likewise. By the same right one might even conclude that production of refuse compost in Switzerland during the next 20 years will be insufficient.

It is very unfortunate that the most important premises on which von Hirschheydt's study rests, are hidden in the concluding sentences: "... if an ex-works price of compost is envisaged." and "No other possibilities were under discussion." Since the sales price affects the profitability of compost plants to a small extent only, this concluding sentence — which can so easily be overlooked — makes the whole study ad absurdum.

Actually, no useful purpose is served by a discussion; instead, the planned sales organization should be set up. The competence in the agricultural field, to which Herr von Hirschheydt - in contrast to "idealists and enthusiasts" — lays claim, could then be used for the common good.

In addition to this discussion mention should also be made of the countless refuse dumps, bulky waste, industrial wastes and clinker from incineration plants. If these were to be covered for cultivation with only as little as half a meter of compost, additional refuse compost would have to be imported.

BOOK REVIEW

Müll und Abfall; Behandlung und Verwertung
(Refuse and Waste Materials; Handling and Utilization)

By Alfons Erbel and Walter Kaupert; Vol. 2 of the series "Fortschrittliche Kommunalverwaltung" (Progressive Municipal Management); G. Grote'sche Verlagsbuchhandlung KG, Cologne and Berlin, 1965; 156 pp. with numerous illustrations, tables, graphs and bibliographic references.

To compress the entire subject of collection, treatment, utilization and disposal of solid waste into the concise form of a pocketbook type of publication, as was done in this work, is no mean task. The main purpose of the work is to acquaint executives in charge of town cleaning with the technical facilities available today in the field of refuse disposal, and to stress the points that must be taken into consideration when endeavoring to solve this problem in a municipality. It is not a scientific work, nor is it intended to vie with the "Müllhandbuch" ["Refuse Manual"] (Refuse and waste disposal — by Kumpf, Maas and Straub) which has already become a standard reference book. Rather, it is a readily digestible abstract from the extensive literature on the subject which can now be followed only by specialists, and does not attempt to go into specific details. This makes it very useful to the field worker, and it undoubtedly fills a gap in the series "Progressive Municipal Administration."

The names of the two authors, who can look back upon many years of successful work in the field of waste disposal, vouch for a well-supported, objective and factually correct presentation of this complex subject.

Br.

Dictionary of Waste Disposal and Public Cleansing

In three languages: German-English-French, by Walter Kaupert; Elsevier Publishing Co., Amsterdam-London-New York, 1966; G. Grote'sche Verlagsbuchhandlung KG, Cologne and Berlin; linen, 225 pp.

A prerequisite for international collaboration is verbal communication. An exchange of thoughts or experiences between experts of different nations is possible only if they share a common language. The lack of a specialized dictionary in the field of waste disposal has long been felt, not only in the study of the literature but also in conversation with experts speaking a foreign language.

A widely used and valuable dictionary of sewage purification, containing many technical terms in several languages, has long been in existence. At long last, the urgent wish of the waste disposal experts has also come true: a dictionary divided into three parts (German-English-French/English-German-French/French-German-English) and containing the most important terms in the field of collection, processing, utilization and disposal of solid wastes, has been published. It is only to be regretted that the three parts of the otherwise very handy dictionary are not distinguished by different colors or divided by a hard partition. This, however, is the only criticism that can be levelled against this valuable work. It will be a very welcome aid to every German, French or English-speaking expert and to all those interested in this field. We wish this trilingual dictionary the widest circulation.

Br.

ANNOUNCEMENTS OF THE SECRETARIAT

Proceedings of the IIIrd International Conference of the IAM, Trento, 1965

Published in German, French, English and Italian, and containing the lectures and supplementary papers may be ordered from: Segretario del Congresso GISRUS, Sign. G. Grassi, Via Belenzani 3, Trento, Italia.

This volume contains the comprehensive versions of the subjects dealt with at the Congress, in abstracts only. it comprises 350 pp., 129 colored illustrations and numerous tables.

Contents:

Langer, W. Beeinflussung der ober- und unterirdischen Gewässer durch Ablagerung fester Abfallstoffe (The Effect of Solid Refuse Dumping on Aboveground and Underground Water Bodies).

Ellis, H. M. Beeinflussung der ober- und unterirdischen Gewässer durch Ablagerung fester Abfallstoffe. Forschungen und Erfahrungen in Grossbritannien (The Effect of Solid Refuse Dumping on Aboveground and Underground Water Bodies. Research and Experiences in Great Britain).

Black, R. J. Amerikanische Erfahrungen auf dem Gebiet der geordneten Deponie (Experiences with Controlled Tipping in the U. S. A.).

Wuhrmann, K. Möglichkeiten und Grenzen der verschiedenen Abfallbeseitigungsverfahren (Diverse Methods for Refuse Disposal — Their Feasibility and Limitations).

Straub, H. Möglichkeiten und Grenzen der verschiedenen Beseitigungsverfahren im Rahmen des gesamten Abfallproblems (Diverse Methods for Refuse Disposal — Their Possibilities and Limitations within the Framework of the Entire Problem of Waste).

Rousseau, H. Die Müllverbrennungsanlage mit Wärmenutzung (Refuse Incineration Plant with Heat Utilization).

Fairlie, P. D. Verbrennungsanlage ohne Wärmeverwertung (Refuse Incineration Plant without Heat Utilization).

Schwartz, K. Massnahmen zur Reinhaltung der Luft bei Müllverbrennungsanlagen (Measures for Maintenance of Clean Air in Refuse Incineration Plants).

Chovin, P. Untersuchungen über die Staubniederschläge in der Umgebung einer Müllverbrennungsanlage (Investigation of Dust Precipitation in the Surroundings of Refuse Incineration Plants).

Riedel, E. O. Ueber die Nützlichkeit des mechanischen Zerkleinerns und Siebens von Abfällen (On the Expediency of Mechanical Crushing and Screening of Refuse).

Erbel, A. Zur physikalischen Aufbereitung des Hausmulls (On Physical Conditioning of Domestic Refuse).

Banse, H. J. and D. Strauch. Die Bedeutung der Vorrotte bei der Kompostierung (The Importance ofPrefermentation in Composting).

Teensma, B. Die Bedeutung der Vorverrottung bei der Kompostierung (The Importance of Prefermentation in Composting).

Maystre, Y. Das Geruchsproblem bei der Kompostierung (The Problem of Odors in Composting).

Braun, R. Das Klärschlamm-Problem (The Sewage-Sludge Problem).

Mendia, L. Das Klarschlamm-Problem in Italien (The Sewage-Sludge Problem in Italy) (This contribution appears only in the Italian edition).

de Fraja Frangipane, E. Stand und zukünftige Entwicklung der Abfallbeseitigung in Italien (Present State and Future Development of Waste Disposal in Italy).

Our New Column "Communications from Industry"

In recent years industrial firms have repeatedly approached us with the request to insert advertisements in our Bulletin. We were unable to comply with this request because the offset print of our publications is unsuitable for this purpose.

However, in order to provide an opportunity for the industries connected with the reclamation and disposal of solid waste to express their views in this specific organ, the I. A. M. executive has decided to introduce a special column in the Bulletin under the heading "Communications from Industry." In this way the firms will be able to inform our readers of new technical developments, modern refuse reclamation plants, special machinery for refuse processing, reports on the results achieved with their products, etc. For the time being this information will appear in the French and German editions only.

These contributions, which may be accompanied by illustrations, should be written in a matter-of-fact and incontroversial style and be of general interest. The I. A. M. Secretariat reserves the right to withhold publication of contributions.

9th International Congress of INTAPUC (International Association for Town Cleaning) to be held in Paris, 26 — 30 July 1967

We wish once more to draw our readers' attention to this important Congress. A letter from the Organizing Committee and a questionnaire for interested persons are attached to this issue.

LITERATURE RECEIVED BY THE SECRETARIAT

Albinus, G. Neue Mullgefasse und Mullbehalter (New Refuse Receptacles and Refuse Bins). – Der Städtetag, Issue 10. 1966.

Andres, O. Zur Wirtschaftlichkeit der Abfallbeseitigung (On the Economics of Waste Disposal). – Der Landkreis, Issue 6. 1966.

Andritzky, M. Erfahrungen mit der Munchener-Anlage zur Mullverbrennung (Experiences in the Operation of the Munich Refuse Incineration Plant). – Die Verwertung und Beseitigung von hauslichen und industriellen Abwasserschlammen, Munchner Beitrage, R. Oldenbourg, Munchen and Wien, Vol. 13. 1966.

Arnst, F. Entwicklungstendenzen bei der Abfallbeseitigung (Development Trends in Waste Disposal). – Der Stadtetag, Issue 9. 1966.

Aue, K. Entscheidung, Voraussetzungen und Vorarbeiten fur eine geordnete Deponie von Abfallstoffen (Choice, Conditions and Preparatory Work for Controlled Tipping of Waste). – Stadtehygiene, 17th year of publ., Issue 6, 1966.

Bishop, W. D., R. C. Carter and H. F. Ludwig. Water Pollution Hazards from Refuse-produced Carbon Dioxide. – Third International Conference on Water Pollution Research, Water Pollution Control Federation, Washington D. C. 20016. Munich. 1966.

Bohme, L. Probenahme von Komposten fur chemische Untersuchungen (Sampling of Composts for Chemical Analyses). – Die örtliche Versorgungswirtschaft, 2nd year of publ., Issue 3, Dresden. 1966.

Braun, R. Zur Frage der Beeinflussung des Grundwassers durch Ablagerungen von Verbrennungsruckstanden und Mullkompost (On the Effect of Incineration Residue and Refuse-Compost Dumps on Groundwater). – Schweiz. Bauzeitung, 84th year of publ., Issue 36. 1966.

Braun, R. Regionale Anlagen fur die Beseitigung von nicht faulnisfahigen Industrieabfallen. Notwendigkeit und Planung (Regional Plants for Disposal of Non-decomposable Industrial Wastes. Necessity and Planning). – Wasser und Luft in der Raumplanung, PRO AQUA 1965, Basle; Verlag R. Oldenbourg, Munchen. 1966.

Braun, R. Der heutige Stand der Schlamm- und Mullkompostierung (The Present State of Sludge and Refuse Composting). – Die Verwertung und Beseitigung von hauslichen und industriellen Abwasserschlammen, Münchner Beiträge, R. Oldenbourg, München und Wien, Vol. 13. 1966.

Busse, O. Praktische Erfahrungen bei der Entwässerung von Abwasserschlammen in Filterpressen (Experience in Dewatering of Sewage Sludges in Filter Presses). – Die Verwertung und Beseitigung von hauslichen und industriellen Abwasserschlammen, Munchner Beitrage, R. Oldenbourg, Munchen and Wien, Vol. 13. 1966.

Chemin, G. Digestion Is Not Really Digestion. Microbiology and Biochemistry of Sludge Digestion. – Water and Sewage Works, Vol. 113, No. 4. April 1966.

Donges, H. J. Die Schlammbeseitigung auf der Emscherflussklaranlage (Sludge Removal at the Emscher River Clarification Plant). – Die Verwertung und Beseitigung von häuslichen and industriellen Abwasserschlämmen, Munchner Beitrage, R. Oldenbourg, Munchen and Wien, Vol. 13. 1966.

Doose, U. Interkommunale Zusammenarbeit (Intermunicipal Collaboration). – Der Stadtetag, Issue 9. 1966.

Doose, U. Probleme des Anschluss- und Benutzungszwanges bei der Mullabfuhr (Problems of Compulsory Linkage to and Participation in the Refuse Collection Network). – Der Stadtetag, Issue 6. 1966.

Einenkel, E. Maschinen in der Mietenkompostierung (Machines in Windrow Composting). – Die ortliche Versorgungswirtschaft, Dresden, 2nd year of publ., Issue 4. 1966.

Eyer, H. Hygienische Proleme bei der Klarschlamm- und Mullverwertung (Sanitary Problems in the Utilization of Sewage Sludge and Refuse). – Die Verwertung und Beseitigung von hauslichen und industriellen Abwasserschlammen, Munchner Beitrage, R. Oldenbourg, München and Wien, Vol. 13. 1966.

Forstner, M. J. and M. Schätzle. Vorschlag fur eine Standardmethode zur Beurteilung der wurmeierabtotenden Wirkung von Abwasserklaranlagen (A Proposed Standard Method for Determining the Ovicidal Effect on Worms by Sewage Clarification Plants). – Die Verwertung und Beseitigung von hauslichen und industriellen Abwasserschlammen, Munchner Beitrage, R. Oldenbourg, Munchen and Wien. Vol. 13. 1966.

Fritschi, E. Bedeutung und Organisation der unschadlichen Beseitigung von Tierkadavern, Konfiskaten und Schlachtabfallen im Rahmen des neuen Tierseuchengesetzes (The Importance and Organization of Innocuous Removal of Carcasses, Confiscated Meat and Abattoir Offal, within the Framework of the New Veterinary Law). – Plan, Vogt-Schild AG., Solothurn, 23rd year of publ., No. 2. 1966.

Giovanoli, C. Abwasser- und Kehrichtbeseitigung in der Ortsplanung (Sewage and Refuse Disposal in Town Planning). – Plan, Vogt-Schild AG., Solothurn, 23rd year of publ., No. 2. 1966.

Guha, P. J. Optimaler Standort fur Abfallbeseitigungsanlagen aus der Sicht der Mulltransportkosten (Optimal Site for Waste Disposal Plants from the Aspect of Collection Costs). – Plan, Vogt-Schild AG., Solothurn, 23rd year of publ., No. 2. 1966.

Hamm, A. Ergebnisse aus Faulversuchen mit Vorerhitzung des Frischschlammes (Results of Experiments in Raw Sludge Digestion with Preheating). – Die Verwertung und Beseitigung von hauslichen und industriellen Abwasserschlammen, Münchner Beitrage, R. Oldenbourg, München and Wien, Vol. 13. 1966.

Harms, A. Sperrmüllzerkleinerung in Wuppertal (Crushing Bulky Refuse in Wuppertal). – Der Stadtetag, Issue 6. 1966.

Hermes, P. Müllverbrennungs- und Müllschlackensinteranlage Berlin-Ruheleben (Refuse Incineration and Refuse Clinker Sintering Plant at Berlin-Ruheleben). – Der Städtetag, Issue 6. 1966.

Hopmans, J. J. Erfahrungen und Ansichten über die Schlammbehandlung in den Niederlanden (Experience and Opinions concerning the Treatment of Sludge in the Netherlands). – Die Verwertung und Beseitigung von häuslichen und industriellen Abwasserschlämmen, Münchner Beitrage, R. Oldenbourg, München and Wien, Vol. 13. 1966.

Huber, L. Die Beseitigung von Schlamm und anderen Abfallprodukten in Erdolraffinerien (Disposal of Sludge and Other Waste Products in Mineral Oil Refineries). – Die Verwertung und Beseitigung von häuslichen und industriellen Abwasserschlammen, Münchner Beitrage, R. Oldenbourg, München and Wien, Vol. 13. 1966.

Imhoff, K. R. Die Eindickung von Schlamm und die Entwässerung von stabilisiertem Schlamm durch natürliche Verfahren (Compressing of Sludge and Further Dewatering of Stabilized Sludge by Natural Processes). –

Die Verwertung und Beseitigung von hauslichen und industriellen Abwasserschlammen, Munchner Beitrage, R. Oldenbourg, München and Wien, Vol. 13. 1966.

Jenfer, O. Mull als Brennstoff (Refuse as Fuel). – Aufbereitungs-Technik, Issue 6. 1966.

Joachim, H. Energie aus Mull unter besonderer Betrachtung der Nutzung zur Klarschlammtrocknung (Energy Derived from Refuse with a View to Its Utilization for Sewage Sludge Drying). – Aufbereitungs-Technik, 6th year of publ., Issue 5. 1965.

Kadisch, E. Strukturverbesserungsmoglichkeiten in schweren Boden Rheinhessens (Ways and Means for Amelioration of the Structure of Heavy Soils in Rhenish Hesse). – Lecture 17, Rheinhess. Weinbauwoche, 2 February 1966.

Kampschulte, J. Grundsatzliches uber das Verbrennen von Haus- und Sperrmull (General Principles in the Incineration of Domestic and Bulky Refuse). – Stadtehygiene, Issue 6. 1966.

Kampschulte, J. Beseitigung von Haus- und Sperrmull sowie besonderen Abfallen (Disposal of Domestic and Bulky Refuse and of Wastes of a Special Nature). – Mull, Abfall, Abwasser, Verlag A. Schweiger, 516 Düren, Issue 1. 1966.

Karnowsky, F. Die Losung des Schlammproblems an der Klaranlage Munchen (Solving the Sludge Problem at the Purification Plant of Munich). – Die Verwertung und Beseitigung von häuslichen und industriellen Abwasserschlammen, Munchner Beiträge, R. Oldenbourg, München and Wien. Vol. 13. 1966.

Kaupert, W. Der Fuhrpark in der Organisation der Stadtverwaltung (The Vehicle Park in Municipal Administration). – Der Städtetag, Issue 8. 1966.

Kaupert, W. Dictionary of Waste Disposal and Public Cleansing; German-English-French. – Elsevier Publishing Company, Amsterdam-London-New York. 1966.

Kehr, D. Die aerobe Schlammstabilisation in den Klaranlagen (Aerobic Stabilization of Sludge in Purification Plants). – Third International Conference on Water Pollution Research, Munich 1966; Water Pollution Control Federation, Washington D. C. 20016. 1966.

Kick, H. Rekultivierung im rheinischen Braunkohlengebiet (Recultivation of the Rhenish Brown-Coal Region). – Mitt. d. Deutschen Landwirtschafts-Gesellschaft, Frankfurt a/M, 81st year of publ., Issue 35. 1966.

Kiess, F. Gemeinsame Behandlung von Klärschlamm und Müll (Treatment of Sewage Sludge and Compost Combined). – Vortragsveröffentlichungen, Haus der Technik e.V., Essen, Vulkan-Verlag, Dr. W. Classen, Essen, 1965.

Klotter, H.-E. and E. Hantge. Ueber die Unsitte des Nasstransportes von Abfallstoffen (On the Bad Habit of Transporting Waste Materials in Wet Condition). – Städtehygiene, Issue 6. 1966.

Knoll, K. H. Umwelthygienische und gesundheitstechnische Probleme und Aufgaben der Gegenwart (Present-Day Problems and Tasks in Environmental Hygiene and Sanitation). – Müll, Abfall, Abwasser, Verlag A. Schweiger, 516 Düren, Issue 1. 1966.

Krichbaum, H. Gebührenmasstäbe für Müllabfuhr und Strassenreinigung (Assessing Refuse Collection and Street Cleaning Fees). – Der Städtetag, Issue 6. 1966.

Kupfer, R. Schlammkonditionierung (Sludge Conditioning). – Die Verwertung und Beseitigung von häuslichen und industriellen Abwasserschlämmen, Münchner Beitrage, Vol. 13, R. Oldenbourg, München und Wien. 1966.

Liebmann, H. Die Bedeutung des Klarschlammes fur die Humusgewinnung. Die Lebensfahigkeit der Wurmeier unter den verschiedenen Bedingungen der Schlamm- und Müllbehandlung. Die naturwissenschaftlichen Grundlagen der Schlammausfaulung und der Methanproduktion. Folgerungen für die Praxis aus den Ausführungen uber die Verwertung und Beseitigung von häuslichen und industriellen Abwasserschlämmen (The Importance of Sewage Sludge in Humus Production. Viability of Worm Eggs under Various Conditions in Sludge and Refuse Treatment. Biological Principles in Sludge Digestion and Methane Gas Production. Practical Conclusions on Utilization and Disposal of Domestic and Industrial Sewage Sludges). — Die Verwertung und Beseitigung von hauslichen und industriellen Abwasserschlämmen, Münchner Beiträge, Vol. 13, R. Oldenbourg, München und Wien. 1966.

Maly, J. and H. Fadrus. Bestimmende Faktoren der Methan-Fermentation des Klärschlammes (Decisive Factors in the Methane Fermentation of Sewage Sludge). — Wasserwirtschaft-Wassertechnik, Issue 1, VEB Verlag für Bauwesen, Berlin. 1966.

McCarty, P. L. Sludge Concentration-Needs, Accomplishments and Future Goals. — Water Pollution Control Federation, Vol. 38, No. 4, Washington. 1966.

Menschel, E. Der Einfluss von Flockungsmitteln auf die Sinkgeschwindigkeit der Eier des Bandwurmes Taenia saginata (The Effect of Flocculants on Settling Velocity of Eggs of the Tapeworm Taenia saginata). — Die Verwertung und Beseitigung von häuslichen und industriellen Abwasserschlämmen. Munchner Beiträge, Vol. 13, R. Oldenbourg, Munchen and Wien. 1966.

Meyer, H. Gemeinsame Verarbeitung von Müll und Klärschlamm nach dem Brikollare-Verfahren (Combined Processing of Refuse and Sewage Sludge by the Brikollare Method). — Die Verwertung und Beseitigung von häuslichen und industriellen Abwasserschlämmen. Munchner Beiträge, Vol. 13, R. Oldenbourg, Munchen and Wien. 1966

Ministère de l'Agriculture, Paris. La commercialisation des composts de résidus ménagères ou résidus urbains obtenus à partir des ordures ménagères. — Techniques et Sciences Municipales, 61st year of publ., No. 8—9, Paris. 1966.

Moe, P. and S. J. Toth. Agricultural Value of Linseed Meal and Hulls. — Compost Science, Spring-Summer, Vol. 7, No. 1. 1966.

Moller, U. Theoretische Grundlagen der Entwässerung von Klärschlamm (Theoretical Foundations of Sewage Sludge Dehydration). — Vortragsveröffentlichungen, Issue 46, Haus der Technik e. V. Essen, Vulkan-Verlag Dr. W. Classen, Essen. 1965.

Mücke. Die Komposttonne — ein Beitrag zur Losung des Müllproblems (The Compost Tank — a Contribution to the Solution of the Refuse Problem). — Städtehygiene, Issue 6. 1966.

Mudrack, K. Die aerobe Schlammstabilisierung (Aerobic Sludge Stabilization). — Die Verwertung und Beseitigung von häuslichen und industriellen Abwasserschlämmen, Münchner Beiträge, Vol. 13, R. Oldenbourg, München and Wien. 1966.

Nebiker, J. H. Die Trocknung des Klärschlammes durch Verdunstung, Untersuchungen über die Verdunstungsvorgänge auf Schlammtrockenbeeten (Sludge Drying by Evaporation: Studies of the Evaporation Process in Sludge Drying Beds). — Schweizer Z. Hydrologie, 27th year of publ., Issue 2, Birkhäuser, Basel. 1965.

Noak, W. Bau und Betrieb von Faulraumen (Construction and Operation of Digestion Tanks). — Die Verwertung und Beseitigung von häuslichen und industriellen Abwasserschlämmen, Munchner Beitrage, Vol. 13, R. Oldenbourg, München and Wien. 1966.

Ochs, H.-J. Der Einsatz von Luftfiltern in Müllverbrennungsanlagen (The Use of Air Filters in Refuse Incineration Plants). — Mull, Abfall, Abwasser, Issue 1, Verlag A. Schweiger, 516 Duren. 1966.

Offhaus, K. Die Problematik bei der Intensivierung der Schlammausfaulung mit Hilfe niederfrequenter Wechselströme (Problems Encountered on Intensifying Sludge Digestion by Means of Low Frequency Alternating Current). — Die Verwertung und Beseitigung von hauslichen und industriellen Abwasserschlammen, Münchner Beiträge, Vol. 13, R. Oldenbourg, Munchen and Wien. 1966.

Oppermann, H. Der Leistungslohn in der Müllabfuhr (Wages for Refuse Collection). — Der Städtetag, Issue 9. 1966.

Perl, K. Korrosionsschäden an Dampfkesseln von Müllverbrennungsanlagen (Corrosion Damage to Boilers in Refuse Incineration Plants). — Energie, Zeitschr. fur praktische Energietechnik, 18th year of publ., Issue 8, Munchen. 1966.

Perl, K. Ermittlung der Ofengrösse einer Müllverbrennungsanlage (Determining the Furnace Size in a Refuse Incineration Plant). — Städtereinigung, 3rd year of publ., Issue 2, Wien. 1966.

Perl, K. La progettazione di impianti per l'eliminazione dei rifiuti urbani. — Rivista Tecnica della Svizzera Italiana, No. 9. 1966.

Pingeon, E. Le transport fluvial des ordures ménagères. — Bulletin No. 16 de l'Association Romande pour la protection des eaux et de l'air, ARPEA, Genève. 1966.

Rasch, R. Müllverbrennung in mittleren Gemeinden (Refuse Incineration in Medium-Sized Communities). — Müll, Abfall, Abwasser, Issue 1, Verlag A. Schweiger, 516 Düren. 1966.

Reichenbach-Klinke, H. H. Schlamm im Vorfluter als Ursache für Fischereischäden (Sludge in the Receiving Water as the Cause of Damage to Fisheries). — Die Verwertung und Beseitigung von häuslichen und industriellen Abwasserschlammen, Munchner Beiträge, Vol. 13, R. Oldenbourg, München and Wien. 1966.

Ruf, M. Die Behandlung radioaktiver Schlämme (Treatment of Radioactive Sludges). — Die Verwertung und Beseitigung von häuslichen und industriellen Abwasserschlämmen, Münchner Beiträge, Vol. 13, R. Oldenbourg, Munchen and Wien. 1966.

Scherb, K. Untersuchungen zur aeroben Schlammstabilisation bei einem neuartigen Belebungsverfahren mit partieller Belüftung und Umwälzung (Studies on Aerobic Stabilization of Sludges by a New Revitalization Method, Involving Partial Airing and Turning). — Die Verwertung und Beiseitigung von häuslichen und industriellen Abwasserschlämmen, Münchner Beiträge, Vol. 13, R. Oldenbourg, Munchen and Wien. 1966.

Schmitt-Tegge, J. D. Abfallbeseitigung, Notwendigkeit und Möglichkeit (Waste Disposal — Its Necessity and Feasibility). -- Der Aargau baut, Gewässerschutz, Issue 2, Verlag Aargauer Tagblatt, Aarau. 1966.

Schneider, F. Die Substanzverringerung von Müll und Müllklärschlamm bei der Kompostierung (The Volumetric Reduction of Refuse and Sewage Sludge in Composting). — Die örtliche Versorgungswirtschaft, 2nd year of publ., Issue 3—4, Dresden. 1966.

Schwarzenbach, F. Praktische Erfahrungen mit dem Müll-Papiersack (Experience with Paper Garbage Bags). — Städtehygiene, Issue 6. 1966.

Sobel, A. T. That Odor! Compost Science, Spring-Summer, Vol. 7, No. 1. 1966.

Sontheimer, H. Verbrennung von Klärschlamm und Müll (The Incineration of Sewage Sludge and Refuse). — Vortragsveröffentlichungen, Issue 46, Haus der Technik e. V., Essen, Vulkan-Verlag, Dr. W. Classen, Essen. 1965.

Sontheimer, H. Erfahrungen bei der Entwässerung von Klärschlamm (Experiences in Dewatering of Sewage Sludge). — Die Verwertung und Beseitigung von hauslichen und industriellen Abwasserschlämmen, Munchner Beiträge, Vol. 13, R. Oldenbourg, München and Wien. 1966.

Sontheimer, H. Die Umsetzung von Kalziumhydroxyd mit organischer Stoffen Schlammentwässerung (Reaction of Calcium Hydroxide with Organic Matter in Dewatering of Sludge). — Third International Conference on Water Pollution Research, Munich, 1966, Water Pollution Control Federation, Washington D. C. 1966.

Stella, P. Versuche zur Klärung der Korrosionsursachen in Müllverbrennungsanlagen (Determining the Causes of Corrosion in Refuse Incineration Plants). — Energie, Z. für praktische Energietechnik, 18th year of publ., Issue 8, München. 1966.

Straub, H. Kompostierung von Schlamm und Müll (Composting of Sludge and Refuse). — Vortragsveröffentlichungen, Issue 46, Haus der Technik e. V., Essen, Vulkan-Verlag, Dr. W. Classen, Essen. 1965.

Tenaille, G. Moscow to Build 600-Ton-per-Day Compost Plant. — Compost Science, Spring-Summer, Vol. 7, No. 1. 1966.

Tope, O. Müll- und Schlackentransport durch Rohrleitungen (Refuse and Slag Transportation by Pipe-lines). — Der Städtetag, Issue 6. 1966.

Tope, O. Unfallverhutung im kommunalen Mullabfuhrbetrieb (Prevention of Accidents in Municipal Refuse Collection). — Der Städtetag, Issue 7. 1966.

Tronko, W. Ein Dezennium Versorgungswasserwirtschaft in der Steiermark (A Decade of Water Supply Services in the Steiermark). — Oesterr. Abwasserrundschau, Series 1—2. 1966.

Van der Kooi, J. Betriebserfahrungen mit der neuen Müllverbrennungsanlage in Rotterdam (Operational Experience at the New Refuse Incineration Plant in Rotterdam). — Müll, Abfall, Abwasser, Issue 1, Verlag A. Schweiger, 516 Düren. 1966.

Vater, W. Verfahren und Geräte für die Entwässerung von Klärschlamm (Process and Implements for Dewatering of Sewage Sludge). — Vortragsveröffentlichungen, Issue 46, Haus der Technik e. V., Essen, Vulkan-Verlag, Dr. W. Classen, Essen. 1965.

Visser, S. A. Some Interrelations between Rates and Types of Fermentation of Plant Material. — Compost Science, Spring-Summer, Vol. 7, No. 1. 1966.

Vogel. Kolloquium über die Beseitigung von Industrieabfällen (Conference on the Disposal of Industrial Washes). — Aufbereitungs-Technik, Issue 6. 1966.

Von Renthe-Fink, B. Abfallbeseitigung in der heutigen Wohlstandsgesellschaft (Waste Disposal in Present-day Affluent Society). — Der Städtetag, Issue 6. 1966.

Wiesli, H. Die Kehrichtbeseitigung auf Anlagen mittlerer Grösse (Refuse Disposal in Medium-sized Plants). — Wasser-Boden-Luft, April 1966.

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EXPERIMENTS WITH WINDROW COMPOSTING OF COMMINUTED DOMESTIC REFUSE

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For many years domestic refuse, comminuted or not, has been composted. This raises several questions which can be answered only on the basis of large-scale experiments, and in 1965 and 1966 we carried out on the experimental grounds of the EAWAG in Tüffenwies-Zurich a series of trials designed for the following purposes:

- Trying out test methods developed in recent times for determining the degree of compost maturation
- Examining the decomposition processes in different layers with windrow heights of 0.5 and 1.5 m
- Comparing decomposition processes of refuse with and without admixture of sewage sludge
- Comparing the decomposition processes in low windrows with and without turning.

Material and Methods

In both 1965 and 1966 four windrows were started with freshly ground domestic refuse from the waste treatment plants in Küsnacht-Zurich and Hinwil-KEZO (Zürcher Oberland), respectively. The Küsnacht plant comminutes the refuse in one coarse and one fine hammermill, frees it of ferrous metals, and screens it in a rotating drum (Dano-Egsetor) provided with holes of 15 mm diameter. The material from Hinwil comes from the Dano-Buhler plant with biostabilizer following coarse grinding, screening on vibration screen with 50 mm hole diameter, and fine grinding of the screenings. This material was piled into windrows A, B, C, and D in 1965, and E, F, G, and H in 1966; the masses are given in Table 1.

The sewage sludge was considered well digested and had a moisture content of 90 – 92%. It was mixed in rotating drums. Because batching is done manually in Küsnacht, the sludge quantities must be considered rough estimates. The material for windrow D was diluted with approximately the same amount of water and was built up similarly to windrow B. At the beginning of the experiments, and after 2, 4, 6, 9, 12, or 13, 20, and 30 weeks small samples of about 3 kg fresh weight were taken from each windrow, and immediately spread out in a thin layer and dried in the ventilator drying cabinet at 25 – 30°C. In the first weeks of the experiment, samples were taken from the fungus zone (grey fungus layer 10 – 30 cm under the surface) and from the core zone (inner layer 40 – 80 cm under the surface). Later and during turning, samples as well mixed as possible were taken from all parts of the windrows.

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TABLE 1. Main data of experimental windrows

Windrow	Origin of material	Dim. m	Height beginning/end, cm	Initial volume, m^3	Approx. weight			Material	
					total kg	sludge kg	water kg	of	deposited on:
A	[illegible]	4 × 7	120/100	22	10,000	5,000	-	19./20.7.66	20.7.66
B	"	2 × 4	110/90	7	3,000	1,500	-	20.7.	20.7.
C		1 × 1	100/80	0.2	100	50	-	20.7.	20.7.
D		2 × 3	120/100	7	3,000	-	1,500	22.7.	22.7.
E	[illegible]	Circle r = 2.0	120/100	5	2,500	300	300	25.4.66	26.4.66
F	"	2.5 × 4	100/80	3	2,500	300	300	26.4.	26.4.
G	[illegible]	Circle r = 2.5	120/100	8	2,500	1,000	-	27.4	27.4
H	[illegible]	2.2 × 4	100/80	5	2,500	1,000	-	27.4	27.4

The temperature was measured daily at depths of 20 and 50 cm and in windrow A also at a depth of 100 cm. Windrows A, B, C, and D were turned after 4, 9, and 20 weeks with a mechanical shovel and, if necessary, wetted by sprinkling water on them; windrows E and G received the same treatment, but only after 4 and 9 weeks. The moisture content and partly the bulk weight and moisture capacity of the fresh material were measured. To carry out the last-named determination, a wire basket of 5 m a mesh and about 1 liter volume was filled with fresh material, put into water for 2 hours, weighed after 2 hours dripping, and check-weighed after drying at 100°C.

The material that had been dried at 25 – 30°C was ground in a ball mill for 3 hours and was used for determining the entire organic matter (OM), the decomposable organic matter (DOM), carbon nitrogen and phosphorus according to the collection of methods of the I. A. M. (1967), as well as for the Chaetomium test (Obrist, 1965).

A plant-growth test after Teensma (1964) was carried out with the dried uncomminuted material in the same way as by Cienciala (1966). For that, young salad plants, about 10 – 12 days old, are singly planted in a mixture of $^3/_4$ peat and $^1/_4$ (by volume) compost, and their state is judged and assessed after 3 and 5 days. Control plants are planted in pure peat moss.

After curing the material, small test plantings were made on the experimental grounds. The compost was applied with normal fertilization in a layer approximately 20 cm thick on clayey soil partly covered by building rubble; tomatoes, cucumbers, onions, radishes, and carrots exhibited good growth without interference or damage. Unfortunately, there was no possibility of comparative plantings in soil.

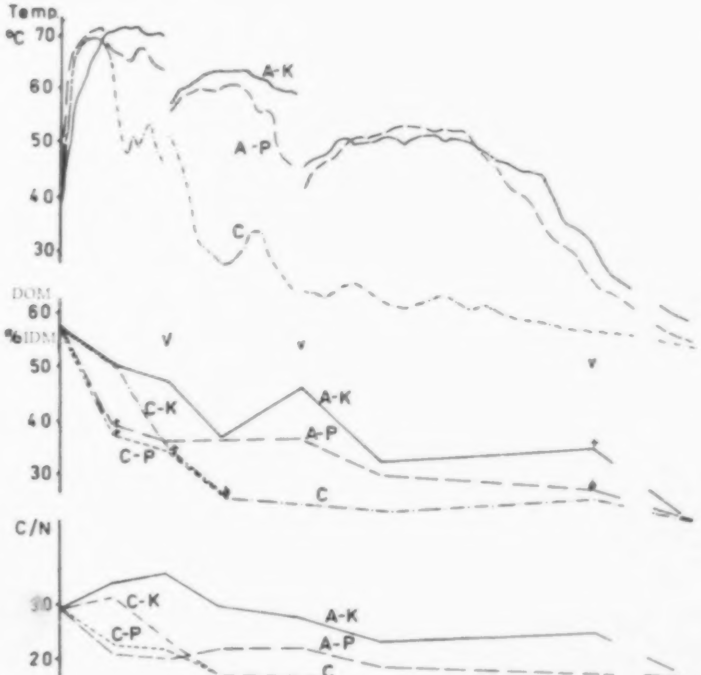
Results and Conclusions

The resulting measurements are given in Table 2, and Figures 1 through 4. The essential findings are:

- The height of the windrow has a considerable effect on the active composting process. If the windrow is up to 1.2 m high, the active composting time can be reduced to 6 – 8 weeks.
- If the windrows are more than 1.5 m high, turning them at intervals of about one month has a very favorable effect on the decomposition process; lower windrows are hardly affected at all.

TABLE 2. Total organic substance in % of dry matter

Windrow	Composting time, weeks							
	0	2	4	6	9	12/13	20	30
A-P	64.7	56.[illegible]	54.9	53.8	54.5	49.5	46.4	42.4
A-K		61.1	61.4	54.5	59.6	49.8	51.9	44.7
B-P		60.6	55.1	51.7	49.9	48.0	43.5	44.0
B-K		62.5	59.3	58.1	60.6	48.7		
C-P		59.4	54.6	46.9	44.6	44.2	45.2	
C-K		62.0	54.2					
D-P	64.4	61.9	52.4	52.1	59.3	46.7	48.0	47.9
D-K		65.9	60.2	59.8	57.1	50.8		
E-P	51.0	42.3	41.1	45.9	35.0	39.7	30.7	27.4
E-K		46.0	41.5	40.1				
F-P		45.2	42.7	44.5	41.4	36.7	32.1	30.6
F-K		50.1	43.9					
G-P	57.[illegible]	54.2	50.2	51.2	49.7	37.6	36.9	32.3
G-K		59.3	61.9	56.2				
H-P		51.[illegible]	51.4	50.8	52.1	40.7	37.9	36.1
H-K		58.4	57.8					



Temp, °C	Windrow temp., °C
DOM% IDM	Decomp. org. matter in % of initial dry matter
C/N	Ratio of carbon (in DOM): nitrogen
V	Turning time
A - K	Windrow A, core zone material
A - P	Windrow A, fungus zone material
C	Windrow C, 20 cm below the surface
C - K	Windrow C, core zone material
C - P	Windrow C, fungus zone material
+	Earliest moment with positive salad test
●	Maturation moment measured with Chaetomium test

FIGURE 1. Decomposition processes in windrows A and C

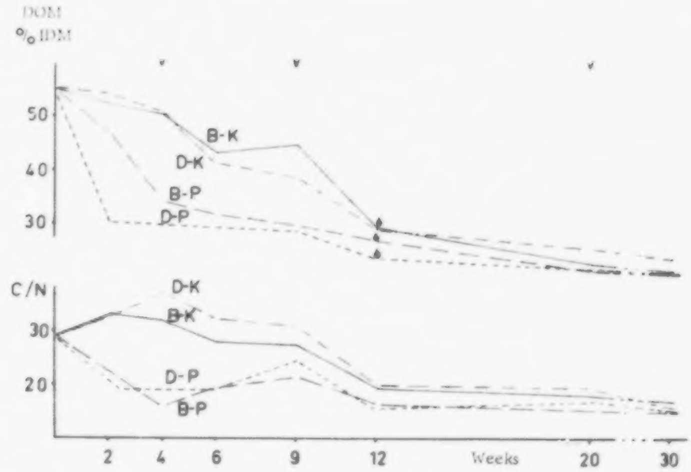


FIGURE 2. Decomposition processes in windrows B and D

DOM % IDM, C/N. V and δ see Figure 1.

B - K	Windrow B, core zone material
B - P	Windrow B, fungus zone material
D - K	Windrow D, core zone material
D - P	Windrow D, fungus zone material

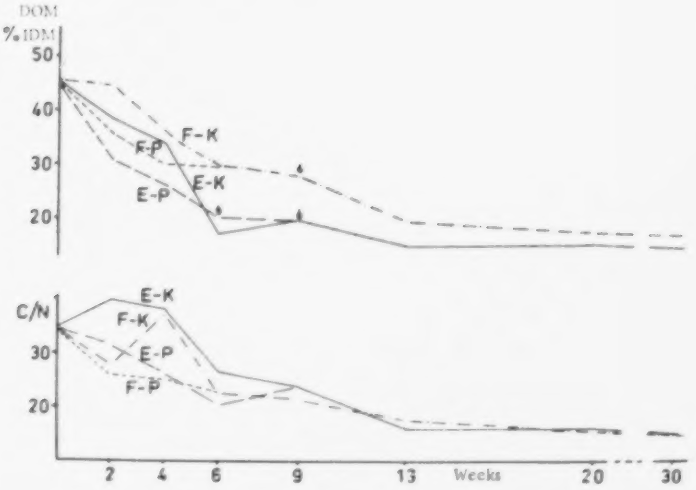


FIGURE 3. Decomposition processes in windrows E and F

DOM % IDM, C/N and δ see Figure 1

E - K	Windrow E, core zone material
E - P	Windrow E, fungus zone material
F - K	Windrow F, core zone material
F - P	Windrow F, fungus zone material

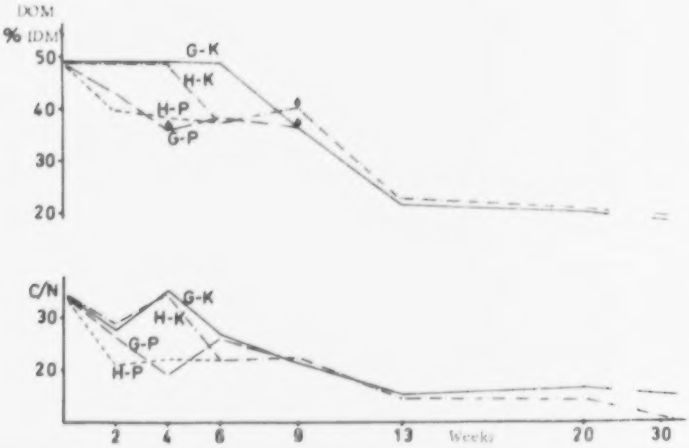


FIGURE 4 Decomposition processes in windrows G and H

DOM % IDM, C/N and δ see Figure 1

G - K	Windrow G, core zone material
G - P	Windrow G, fungus zone material
H - K	Windrow H, core zone material
H - P	Windrow H, fungus zone material

- In the outer layer, or fungus zone, 40 – 60 cm deep, in windrows more than 1.5 m high the active composting process takes an entirely different course from that in the inner layer or core zone. In the fungus zone, maturation degree (measured by the Chaetomium test), C/N ratio, decomposition of organic matter, and especially the effect on the salad test plants attain much more quickly better values, guaranteeing sufficient maturation, than in the core zone material. However, the material in the fungus zone represents only a small fraction of the entire windrow's volume so that the preponderant part of the material requires a much longer period of maturation.
- The addition of sewage sludge in our experiment has no significant effect. The C/N ratio is hardly improved while the decomposition in the comparable windrows B and D progresses approximately equally.
- A comparison between refuse screened in the Egsetor and predigested in the Dano-biostabilizer does not yield any considerable differences in the course of active composting, but the refuse from the latter decomposes more rapidly during the first weeks. The reason could be that the refuse treated in the biostabilizer already contains a quantitatively larger decomposable flora of microorganisms.
- The important part played by moisture and aeration is illustrated by a comparison of the decomposition curves of organic substances of windrows E and F. Whereas windrow E, which had been turned and moistened twice, exhibited rapid decomposition, the active composting process in windrow F proceeded more slowly, although it had been more quickly and completely saturated with fungus, than had windrow E. Windrow F had not been turned, and dried up too much within a relatively short time, thus considerably retarding the decomposition processes.

- Among the test methods investigated for the degree of active composting and maturation, the determination of the C/N ratio and the Chaetomium test were found suitable but time-consuming. The salad test is quicker, but even at an early stage of active composting it is positive again, so that it cannot always be used to determine maturation. In Holland (Teensma 1966), too, the test was not developed further. With fresh refuse, the test is also positive; this indicates that certain intermediate products of decomposition cause a reaction which occurs at the time of the most intensive active composting.

These investigations also confirmed the fact that while small windrows have a much shorter active composting time than larger ones, moisture and aeration factors contribute considerably to an optimum course of active composting.

Bibliography

Cienciala, M. Faktoren des Reifeprozesses einiger schweizerischer Mullkomposte (Factors of the Maturation Process of Some Swiss Waste Composts). – I.A.M. Informationsblatt 28, pp. 75 – 86. 1966.

I.A.M. Internationale Arbeitsgemeinschaft fur Mullforschung. Methoden zur Untersuchung von Mull, Mullschlacken und Mullkompost (Methods of Investigating Waste, Residues, and Compost). – Sekretariat der I.A.M., Zurich (in press).

Obrist, W. Enzym-Aktivitat und Stoffabbau im rottenden Mull; Vorschlag fur eine neue mikrobiologische Methode zur Bestimmung des Rottegrades (Enzyme Activity in Refuse during Active Composting; Proposed New Microbiological Method of Determining the Degree of Active Composting). – I.A.M. Informationsblatt 24, pp. 29 – 37. 1965.

Teensma, B. Verslag van de proefnemingen over het jaar 1964, Issue 19. Amsterdam, Stichting "Compost," Afdeling Landbouwzaken. 1964. Communication by Letter. 1966.

ON THE LAYOUT OF WASTE INCINERATION PLANTS

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Owing to the steadily increasing amount of waste, the controlled disposal of municipal waste assumes increasing importance. Waste incineration is the predominant method in densely populated industrial areas, giving rise to a number of special problems. In the first place, incineration is hindered by the greatly changing composition of refuse. Planning for a waste incineration plant, therefore, requires extensive analyses of the refuse in the projected plant's collection area so that its optimum operation may be ensured.

Refuse composition is dependent on the most varied factors, and it also differs in individual towns, so that empirically collected values of one town's waste incineration plant cannot be applied automatically and without change to another town.

Because of the differences occurring in refuse, it is very difficult to obtain reliable values, and if the values found are to be of practical use, many analyses have to be carried out over a long time (at least 1 year).

A waste incineration plant has to be so planned that waste of even the most extreme composition within the collection area can be incinerated.

On superficial observation of waste, no signs of possible similarity between individual waste components can be noticed. More detailed investigations, however, reveal that the main components of the combustible content are similar to cellulose. An exception is winter refuse from areas where domestic heating uses bituminous coal predominantly. Owing to the incomplete combustion of bituminous coal in domestic stoves, the clinker in these regions contains a high percentage of coke.

In (1) are listed the values of combustion heat of clinker- and moisture-free substances V_{awf} of the main combustible waste components.

	Proportion in waste, %	V_{awf}, cal/kg
Paper and wrapping material	5 . . . 32	4,540
Vegetable and other kitchen waste	6 . . . 18	4,900
Textiles, leather, rubber	3 . . . 8	4,730
Wood, straw, garden refuse	2 . . . 5	4,900

Here V_{awf} corresponds to H_{awf} given in (1).

If we calculate the mean values of the respective components in the waste, the mean value of V_{awf} works out at:

$$V_{awf} = 4710 \approx 4700 \text{ cal/kg}$$

The combustion heat values of the combustible substances given above show that they differ only by about 5% from the mean value of $V_{awf} = 4700$ cal/kg. It is possible, therefore, to assume a constant value for the combustion heat of waste components similar to cellulose.

Another large component of the refuse is ash from domestic heating. In it, the combustible component consists almost exclusively of coke. The combustion heat of the ash- and moisture-free substance in domestic ash, therefore, can be assumed to equal the combustion heat of pure carbon

$$V_{awf} = 8100 \text{ cal/kg}$$

Thus, if the individual components of waste are known, the combustion heat can be calculated mathematically.

Dependence of Caloric Value of Waste on Its Ash and Moisture Content

The dependence of the caloric value of waste on the composition of the waste is analyzed below.

Figure 1 illustrates the dependence of the combustion heat of ash- and moisture-free substance V_{awf} on the ash content of moisture-free waste a_{wf}. The values entered were taken from (2), (3), (4), (5), and investigations carried out by the Institute of Communal Economics in Dresden.

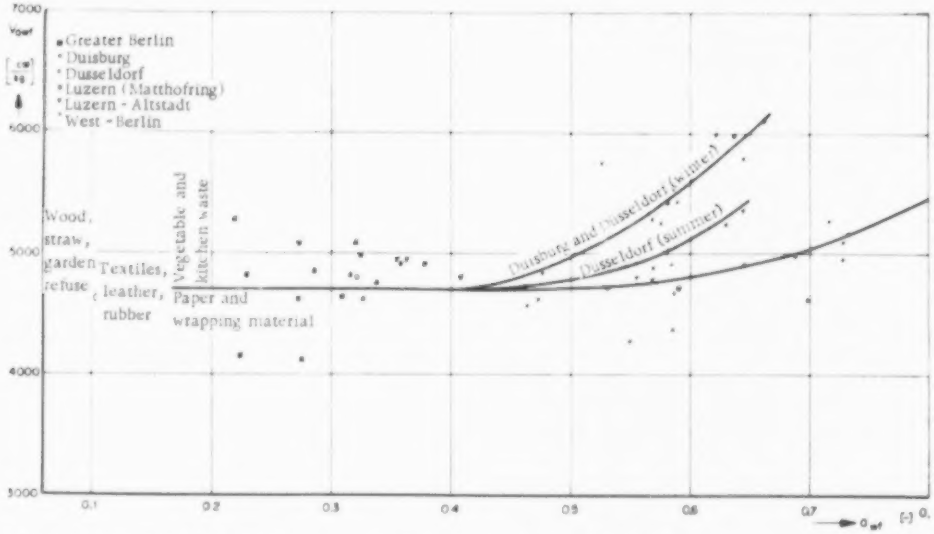

FIGURE 1. Combustion heat of ash- and moisture-free substance V_{awf} in dependence on ash content of moisture-free waste a_{wf}

Figure 1 shows that the combustion heat of the ash- and moisture-free substance V_{awf} is indeed dependent on the ash content of the moisture-free waste a_{wf}. Three characteristic areas can be detected.

a) Areas where dwellings are heated preponderantly with bituminous coal. In these areas, the combustion heat V_{awf} increases in the winter months, especially markedly when the proportion of domestic ash is large. This phenomenon is determined by incomplete combustion of bituminous coal in domestic stoves.

b) Areas where dwellings are heated preponderantly with brown coal. These areas are marked by particularly high ash content in the winter months, due to the high ash content of brown coal. However, because brown coal is burned fairly completely in general, V_{awf} increases only slightly with increasing ash content a_{wf}.

c) Areas with small ash content. These are areas with district heating or types of heating not using coal, and in them, the proportion of paper in the refuse is particularly large. The caloric value of the combustible substance remains constant.

It was established that in winter especially great differences are found in the waste composition. In summer, the waste composition in the three areas is very similar because domestic ash represents only a small proportion of the waste in that season.

Figure 1 also shows that some measured values deviate considerably from the mean value for several reasons.

a) The waste is of different composition while the ash content of the moisture-free waste is the same. Thus, deviations toward higher values can be a consequence of abnormally high admixtures of coke or coal, although this is not the main cause of the deviations.

b) The composition of the samples for determining combustion heat, ash content and moisture content was unequal, which is probably the main reason for deviations as the mean from a number of measurements is usually close to the theoretical value. For deviations to below $V_{awf} = 4{,}500$ cal/kg, this may be the only reason.

c) Ash content, moisture content, or combustion heat were wrongly determined, but this is rarely the cause of deviations.

Compared with the absolute variations in caloric value of raw refuse, the deviations are slight.

It can be said with sufficient assurance, therefore, that the combustion heat of ash- and moisture-free substance V_{awf} is dependent on the ash content of the moisture-free waste a_{wf}, and vice versa.

$$V_{awf} = f(a_{wf})$$

Applied, this is

$$a_{wf} = \frac{a}{1 - w}$$

where a = ash content of raw waste; w = moisture content of raw waste.

The foregoing shows that V_{awf} depends on the ash content a and on the moisture content w of the raw waste. The combustion heat of raw waste is

$$V = V_{awf} \cdot b$$

where b = 1-a-w = ash- and moisture-free substance of the waste.

For the combustion heat, the formula is:

$$V = f(a, w)$$

As regards the waste composition, the assumption may be made that it consists of a celluloselike component and ash from domestic heating.

If assumption is made that the combustible substance of domestic heating ash contained in the waste remains constant, the following relations for the combustion heat of the moisture-free waste can be formulated

$$V_{wf} = b_Z \cdot Z \cdot 4{,}700 + b_H \cdot H \cdot 8{,}100 \qquad (1)$$

Where:

Z = celluloselike component in the refuse (kg/kg refuse);

H = proportion of domestic heating ash in the refuse (kg/kg refuse);

bZ = combustible substance of the celluloselike component;

bH = combustible substance in the domestic heating ash.

For further calculation, the stipulation is that the refuse consists only of domestic heating ash and celluloselike matter. The noncombustible part of the refuse is assumed to be the noncombustible proportion of the celluloselike matter.

This is formulated as

$$Z + H = 1$$

Because the combustion heat of ash- and moisture-free waste, according to Figure 1, depends on the ash content of the moisture-free waste, the waste composition must also depend on a_{wf}.

That may be expressed

$$Z\,(1-b_Z) + H\,(1-b_H) = a_{wf} \geq (1-b_Z) \tag{2}$$

For the value $a_{wf} \leqq (1-bZ)$, $Z = 1$ and $H = O$.

This waste, as a rule, no longer contains any domestic heating ash.

For waste from areas heating preponderantly with brown coal, the evaluation of the correlation between V_{awf} and a_{wf}, plotted in Figure 1, yields the following values for the combustible components.

$$b_Z = 0.5 \text{ and } b_H = 0.06$$

Then

$$Z = \frac{0.94 - a_{wf}}{0.44} \tag{2a}$$

For the combustion heat of waste from areas using preponderantly brown coal in domestic heating, the following formula applies

$$V_{wf} = 4{,}468\,(1-0.948\,a_{wf}) \geq 4{,}700\,(1-a_{wf}) \left[\frac{\text{cal}}{\text{kg}}\right] \tag{1a}$$

Consequently, the combustion heat of the ash- and moisture-free substance is

$$V_{awf} = \frac{V_{wf}}{1-a_{wf}} = 4{,}236 + \frac{232}{1-a_{wf}} \geq 4{,}700 \left[\frac{\text{cal}}{\text{kg}}\right] \tag{3}$$

or

$$V_{awf} = 4{,}236 + 232\,\left(\frac{1-w}{b}\right) \geq 4{,}700\,\frac{\text{cal}}{\text{kg}} \tag{3a}$$

For the layout of a furnace, however, the combustion heat is not decisive, and another relation for the caloric value has to be obtained.

In combustion of pure carbon, the caloric value and the combustion heat would be equal so that the caloric value in the waste incineration of pure domestic ash could be written

$$Hu_{(H)} = V_{awf} \cdot b - 600\,w$$

However, for combustion of the cellulose-like component in waste this relation would be very inaccurate because incineration liberates additional water due to hydrogen component in waste. The evaporation heat of the liberated water, in reference to the combustible substance, amounts to about 320 cal/kg.

The caloric value of the celluloselike component then becomes

$$Hu_{(Z)} = (V_{awf} - 320)\,b - 600\,w$$

Thus, we can write for the caloric value of the waste

$$Hu = \left\{(4{,}700-320)\,b_Z\,Z + 8{,}100 \cdot b_H \cdot H\right\}(1-w) - 600\,w\,\frac{\text{cal}}{\text{kg}} \tag{4}^*$$

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* In the original erroneously numbered "5".

From this, we obtain the relationship for the caloric value of waste from areas with domestic brown-coal heating:

$$Hu = 4{,}122 - 4{,}722\ w - 3{,}871\ a\ \frac{cal}{kg}\ \text{for}\ \frac{a}{1-w} \geq 0{,}5$$

$$Hu = 4{,}381\ b - 600\ w\ \frac{cal}{kg}\ \text{for}\ \frac{a}{1-w} \leq 0{,}5$$

It follows from the foregoing that the caloric value, too, depends only on the ash and moisture content of the waste.

$$Hu = f\,(a,\ w).$$

It is thus possible to represent the different compositions of waste in a three-phase diagram (henceforth designated waste triangle). Figure 2 is such a diagram for waste from areas heating preponderantly with domestic brown coal.

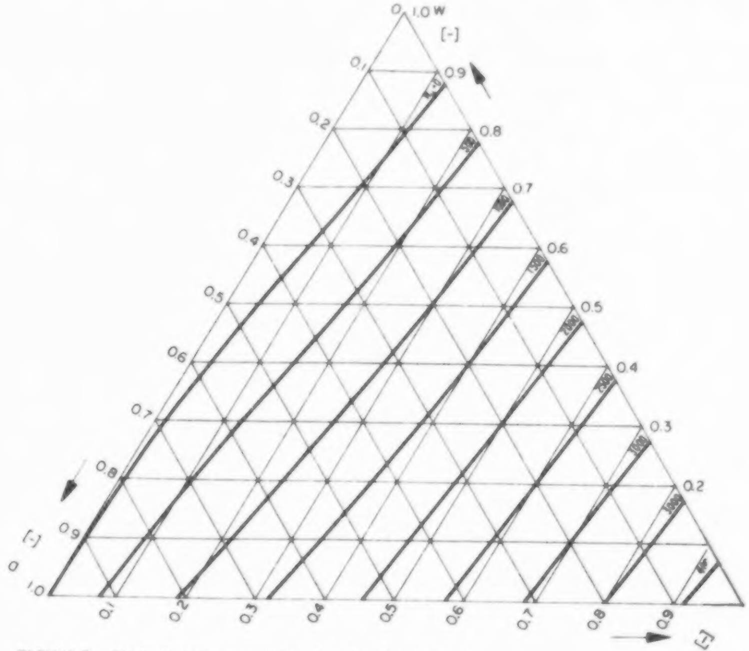

FIGURE 2. Waste triangle representation of caloric values

Dependence of Air Requirement on Waste Composition

Because the elementary analysis of the waste must be known if the requirement of air is to be determined, elementary analyses from various waste collection areas were made. Waste with an ash content of the moisture-free substance

$a_{wf} < 0.5$ gave the following mean values for the elementary analysis of the ash- and moisture-free substance:

$$c_Z = 0{,}515 \; ; \; h_Z = 0{,}062 \; ; \; n_Z = 0{,}015 \; ; \; s_Z = 0{,}015 \; ; \; o_Z = 0{,}393.$$

The subscript Z indicates that these values apply to the celluloselike component of the waste.

For wood, the following mean values were found in the elementary analysis:

$$c = 0{,}5 \; ; \; h = 0{,}06 \; ; \; n = 0{,}01 \; ; \; o = 0{,}43.$$

The two analyses obviously differ from each other little.

In the case of domestic ash, however, this composition changes because the combustible substance of domestic ash consists almost exclusively of carbon.

Thus the values of the elementary analysis for the ash- and moisture-free substance of waste with an ash content of the moisture-free waste $a_{wf} > 0.5$ amount to

$$c = \frac{c_Z \cdot Z \cdot b_Z + H \cdot b_H}{1 - a_{wf}} \tag{5}$$

and in particular for the conditions in areas which heat predominantly with brown coal

$$c = 0{,}45 + \frac{0{,}003}{1-a_{wf}} \geqq 0{,}515 \tag{5a}$$

For the other components of the waste, conversion is carried out through multiplication with $Z \cdot b_Z / (1-a_{wf})$

$$h \; ; n \; ; s \; ; o \; ; = (1{,}14 + \frac{0{,}07}{1-a_{wf}})\, h_Z \; ; n_Z \; ; s_Z \; ; o_Z \; ; \approx h_Z \; ; n_Z \; ; s_Z \; ; o_Z \tag{6}$$

With these elementary analysis values, the air requirement for incineration of waste can be determined. According to (6) the minimum air requirement is

$$L_{min} = \frac{O_{min}}{0{,}21} = \frac{K \cdot \sigma}{0{,}21} \left[\frac{m^3 \text{ STP}}{\text{kg waste}} \right]$$

Here applies:

$$K = 1{,}867 \cdot c \text{ and } \sigma = 1 + \frac{3}{c}(h - \frac{o-s}{8}).$$

Thus, we obtain the following air requirement for the ash- and moisture-free substance of the waste:

$$L_{min}(a_{wf}) = \frac{1{,}867}{0{,}21} \left[c + 3\,(h - \frac{o-s}{8}) \right] \geqq \frac{K_Z \cdot \sigma_Z}{0.21} \left[\frac{m^3 \text{ STP}}{\text{kg waste}} \right] \tag{7}$$

and for waste from areas heating with brown coal:

$$L_{min}(a_{wf}) = 4.83 \frac{0{,}296}{1-a_{wf}} - 0{,}895\, a_{wf} \geqq 4{,}95 \left[\frac{m^3 \text{ STP}}{\text{kg waste}} \right] \tag{7a}$$

Because the composition of waste varies considerably, it is futile to exaggerate accuracy in calculations, and calculation of the minimum air requirement for ash- and moisture-free substance can be simplified even more. Evidence from the literature and from subsequent calculations shows that the ash content of moisture-free waste should not exceed 75%. It follows that the value of σ lies within the limits $1.086 = \sigma > 1.035$. If $\sigma = 1.06$ is taken as a fixed value, the maximum error would amount to ± 2.5%. Thus the formula for the minimum air requirement is:

$$L_{min\,(a_{wf})} = \frac{1.867 \cdot \sigma \cdot c}{0.21} \tag{8}$$

and for the special case

$$L_{min\,(a_{wf})} = 4.24 \cdot \frac{0.311}{1-a_{wf}} \leq 4.85 \frac{m^3\ STP}{kg\ waste}. \tag{8a}$$

This equation is sufficiently accurate for the purpose of waste incineration. The minimum air requirement L_{min} for raw waste thus amounts to:

$$L_{mm} = L_{min\,(a_{wf})} \cdot b \frac{m^3\ STP}{kg\ waste}. \tag{8b}$$

Actual air requirement is:

$$L = L_{min} \cdot n \frac{m^3\ STP}{kg\ waste}.$$

For waste incineration we take $n = 1.5 \ldots 1.7$.

In Figure 3, the waste triangle shows the minimum air requirement L_{min} for waste incineration.

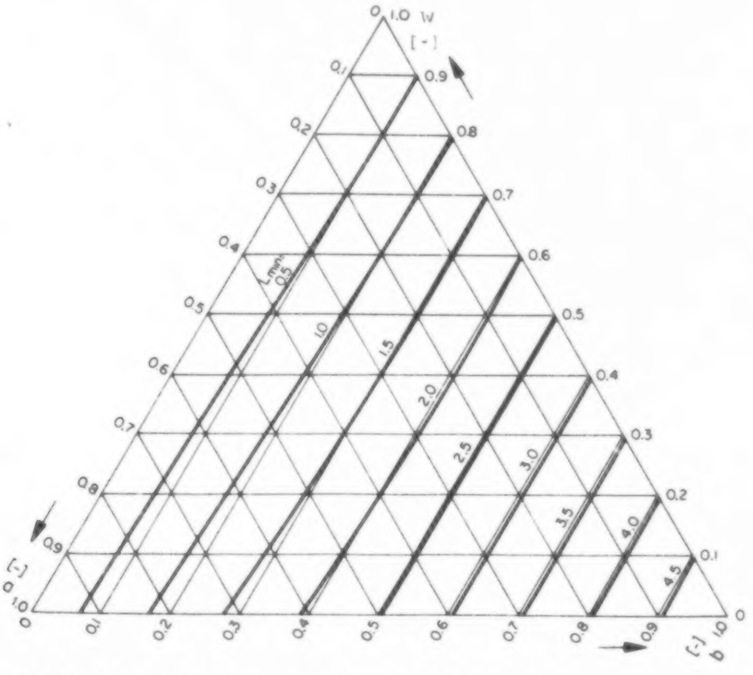

FIGURE 3. Waste triangle representation of minimum air requirement

Determination of Flue Gas Volume from Waste Composition

For the flue gas volume, according to (6) applies:

$$V_f(a_{wf}) = [1 + \omega + \xi + \vartheta + \sigma\,(4.76\,n - 1)]\,K \qquad (9)$$

where

$$\omega = \frac{2}{3}\left(\frac{9h + w}{c}\right)\,;\quad \xi = \frac{3}{8}\cdot\frac{s}{c};\quad \vartheta = \frac{3}{7}\cdot\frac{n}{c}$$

The relation for flue gas volume can be transformed as follows:

$$V_f(a_{wf}) = [(1 + \xi + \vartheta - \sigma) + (\omega + 4{,}76\cdot\sigma\cdot n)\,K$$

If we put

$$(1 + \xi + \vartheta - \sigma) = 0$$

the resulting error is less than 1%. Thus, the formula for the flue gas volume of the ash- and moisture-free substance is simplified to:

$$V_f(a_{wf}) = [\omega + 4{,}76\cdot\sigma\cdot n]\,K\left[\frac{m^3\ \text{STP}}{\text{kg waste}}\right]$$

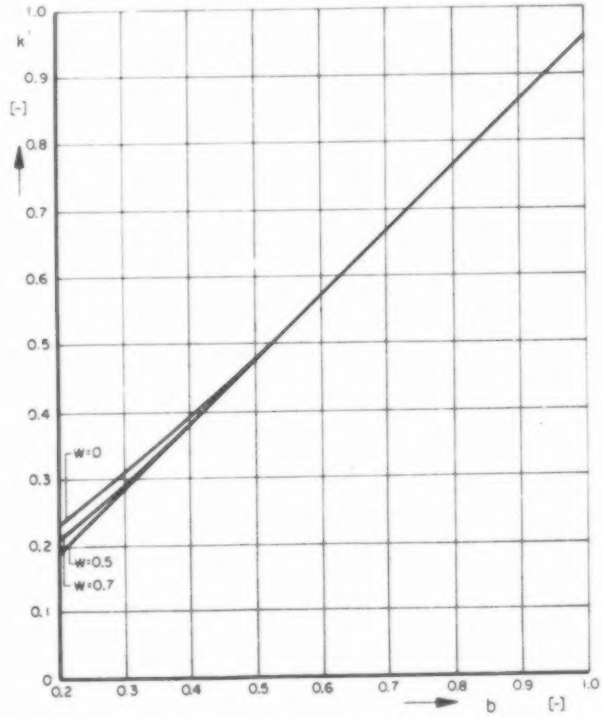

FIGURE 4. K' in dependence on combustible substance of waste

We then obtain for the flue gas volume of the raw waste

$$V_f = [\omega + 4.76 \cdot \sigma \cdot n]\ K \cdot b = [\omega + 4.76 \cdot \sigma \cdot n]\ K' \left[\frac{m^3\ STP}{kg\ waste}\right] \qquad (9a).$$

Here, as in determining the air requirement, we assume that $\sigma = 1.06$. Consequently, the following relation applies to K':

$$K' = \left[0.84 + \frac{0.0615}{1 - a_{wf}}\right] b \geqq 0.96 \cdot b$$

In Figure 4, K' is represented as a function of the combustible substance. The flue gas volume can be read off the nomograph shown in Figure 5.

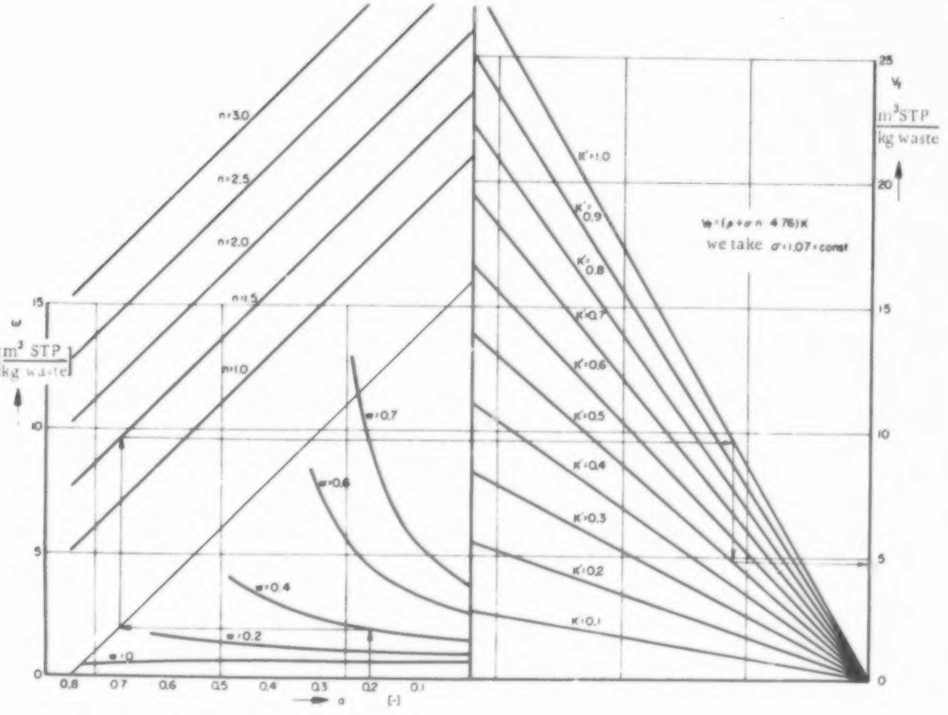

FIGURE 5. Nomograph for determining flue gas volume

Determination of Incineration Efficiency as a Function of Waste Composition

For the layout of waste incineration plants, it is important to know the incineration efficiency.

Incineration efficiency includes the following partial losses:

a) radiation loss in the region of the combustion space	q_{str}
b) losses due to unburned material in the clinker	q_u
c) losses due to heat content of the clinker	q_s
d) losses due to unburned material dropped through the grate	q_v
e) losses due to imperfect combustion	q_{co}

In the subsequent calculations, the material dropped through the grate is taken together with the clinker. Losses due to imperfect combustion are neglected because in waste incineration combustion is almost complete owing to the great excess of air.

Thus the incineration efficiency is:

$$\eta f = 100 - q_{str} - q_u - q_s \ [\%] \qquad (10)$$

Radiation losses are given as 2%, which is the upper limit for steam generators of the size usual in waste incineration. The caloric value of the unburned material in the clinker was taken as the caloric value of pure carbon, Hu = 8,100 cal. Various examinations of clinker showed that the unburned part consists almost exclusively of coke. The temperature of clinker at the removal point was given as $t_s = 500°C$ and the mean specific heat of clinker as $c_{m(S)} = 0.23 \ \frac{cal}{kg\ deg}$.

Thus the formula for heating efficiency becomes

$$\eta f = 1 - \frac{(115 + 8{,}100\ b_S)\ a}{Hu} - 0.02$$

with b_S being the combustible substance in clinker.

In Figure 6, lines are plotted of constant efficiency of the combustion space as a function of the combustible substance in the clinker, and of the ash content of the moisture-free waste.

From this diagram the combustion efficiency for any composition of the waste can be determined in the waste triangle situated above the diagram.

Equation (10a) shows that if the content of combustible substance in the clinker remains constant

$$\eta f = \text{const. for } \frac{a}{Hu} = \text{const.}$$

This would apply exactly for straight lines through the point representing pure water, if at this point Hu were equal to zero. However, theoretically, we obtain for the pure water point Hu = 600 cal/kg. This corresponds to evaporation heat of water.

At the intersection point of the lines of constant combustion-space efficiency all the possible values of $\eta = 0 \ldots 1$ must be realized. This, however, applies only to points Hu = 0 and a = 0. But, on straight lines through this point, Hu does not decrease exactly linearly. In the usual range of waste incineration the deviations are so small that for Hu/a = constant, straight lines may be assumed in the waste triangle. The point of intersection of the lines of constant combustion efficiency lies at a = 0 and w = 0.88, and is designated "P." Once "P" has been fixed, the combustion efficiency can be determined for any point in the waste triangle.

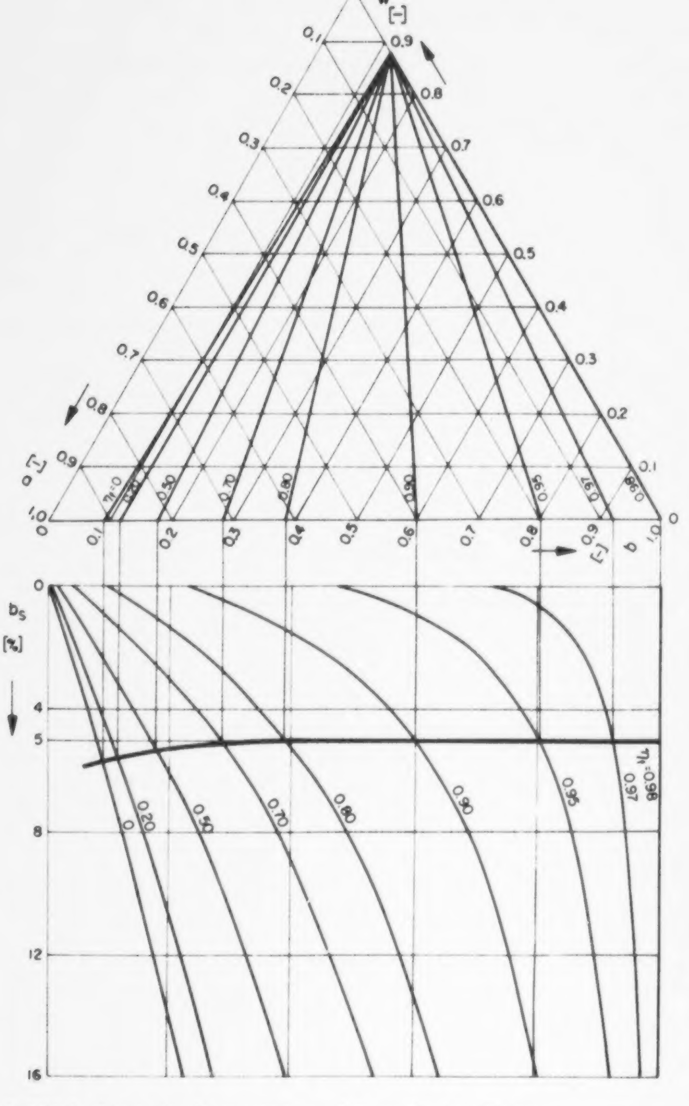

FIGURE 6. Waste triangle representation of the combustion efficiency

The thick line for the combustible substance in the clinker in Figure 6 takes into account the fact that the clinker of the celluloselike component still contains 5% combustible substance, and that domestic ash does not burn any further.

Determination of Combustibility Boundary and Comparison with Combustibility Boundary Given by Tanner

The boundary of waste combustibility is taken as the combustion space temperature t_f that can be attained. The boundary values were fixed as follows from data from the literature:

$$900°C \leqq t_f \leqq 1{,}000°C$$

The calculation is based on an air ratio $n = 1.7$. The upper limit for the preliminary heating of the combustion air was taken as $t_L = 300°C$. The boundary of waste combustibility was fixed at

$$t_f = 900°C - \text{const. (for } t_L = 300°C\text{)}.$$

Left of this boundary curve, supplementary combustion has to be used.

The line for $t_f = 1.000°C$ = const. (for $t_L = 20°C$) sets the limit for flue gas reverse suction. On the right of the curve, flue-gas reverse suction would have to be used.

However, the boundary curves given above apply only to uncooled combustion spaces.

This description of the combustibility boundary contrasts with the combustibility boundary given by Tanner (7). Below follows an attempt at comparing the two combustibility boundaries.

Tanner divides the combustibility boundary into three sections. They are

ash content	$a \leqq 0.6$
moisture content	$w \leqq 0.5$
and content of burnable substance	$b \geqq 0.25$

Both combustibility limits are shown in Figure 7.

It was found that the combustibility boundaries for the sections given by Tanner, $a \leqq 0.6$ and $w \leqq 0.5$, deviate considerably from the graph of constant combustion space temperature. The partial sections given by Tanner, therefore, will be compared individually with the boundary curves of constant combustion-space temperature.

a) Partial section $b \geqq 0.25$

This section was not explained in Tanner's report, beyond saying that this value was determined largely from experiments.

An explanation of this boundary curve is that in waste incineration a certain amount of heat energy must be available for heating the flue gases and slag, and for evaporating moisture. Since combustion to the right of the combustibility boundary should be effected without supplementary combustion, the required heat energy must be liberated during the incineration of the waste. A certain proportion of combustibles, therefore, must be maintained.

The calculation shows that the value $Hu \cdot \eta f$ for b = constant remains indeed approximately equal, which explains that this section of the combustibility boundary coincides approximately with the calculated combustibility boundary. Preheating of the combustion air to 300°C thereby corresponds approximately to the maximum values used.

b) Partial section $a \leqq 0.6$

Tanner writes for point y beyond this boundary curve:

"Although the proportion of the fuel exceeds the required minimum of 25%, this waste would not burn unaided because the high ash content isolates the

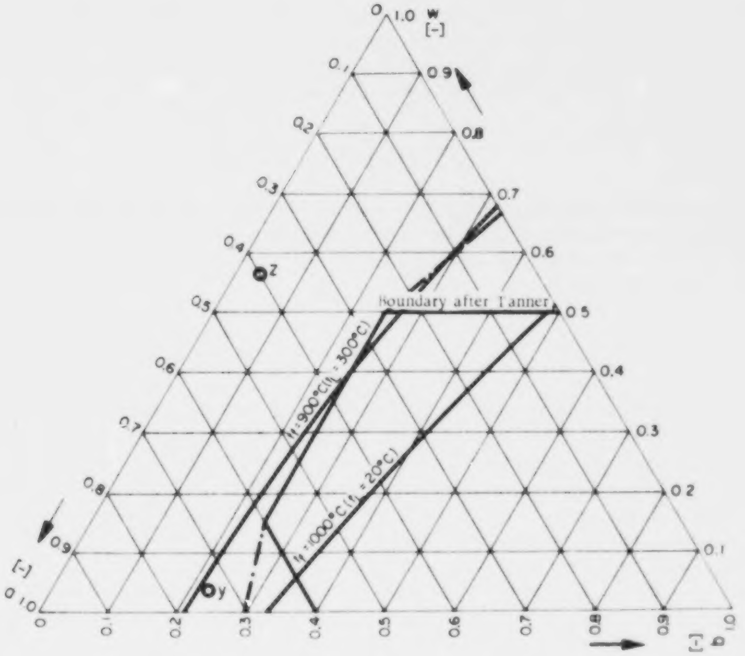

FIGURE 7 Representation of combustibility boundaries in the waste triangle

individual fuel components from each other to such an extent that continuous combustion could not be effected."

Thus. Tanner fixes the ash content of raw waste as the boundary of combustibility. Since drying of the waste precedes its incineration, however, the ash content of the moisture-free waste should be taken as the boundary value according to the reasoning given. This boundary value lies on a straight line passing through the point of pure water. The boundary value for the ash content of moisture-free waste amounts to

$$a_{wf} = \frac{a}{1-w} = \frac{0.6}{0.75} = 0.706$$

This boundary value was also entered in Figure 7, when it was found not to differ substantially from the calculated boundary of combustibility. The mathematically calculated boundary of combustibility is still slightly flatter because a smaller amount of heat is required for evaporating the decreasing moisture content.

c) Partial section $w \leqq 0.5$

Tanner writes for point z beyond this boundary curve:

"The moisture of this waste is so high that the small proportion of fuel does not suffice for drying."

However, because the proportion of combustible substance depends on the ash content as well as the moisture content, this datum for the boundary curve is also inaccurate. The boundary value really should be the line with a constant ratio of moisture content to content of combustible substance. This would be the line of constant moisture content of the ash-free waste. This boundary value lies on a straight line that passes through the point of pure ash. Then, the moisture content of ash-free waste is

$$w_{af} = \frac{w}{1-a} = \frac{0.5}{0.75} = 0.667$$

This then shows that the boundary value and the mathematically calculated boundary of combustibility do not differ substantially. The steeper slope of the calculated boundary of combustibility is caused by the increase of combustion efficiency.

Summary

The report was intended mainly to explain data hitherto known from the literature, and if possible, to provide such data with a theoretical foundation. The special equations and the diagrams given here are valid only for waste collection in areas with district heating and areas using mainly brown coal. n coal. For areas where bituminous coal is used for heating, the special equations would have to be derived from general equations. The given boundaries of combustibility are valid only for combustion spaces without cooling.

This paper is not comprehensive because research in the field of waste incineration has been taken up only recently in the Institute of Communal Economy in Dresden, where this work was carried out.

Bibliography

Kumpf, Maas, Straub. Müll- und Abfallbeseitigung (Waste and Refuse Disposal). — Kennzahl 7010, p. 6.

Ehrig, H. Die Planung der Mullverbrennungsanlage Duisburg (Planning the Duisburg Waste Incineration Plant). — Mitteilung des VGB, Issue 75, pp. 438—446. December 1961.

-- Prospect Durrwerke Aktiengesellschaft Ratingen (Prospectus of Durrwerke Aktiengesellschaft Ratingen).

Bopp, R. Betrachtungen zur Mullverbrennung (On Waste Incineration). — Aufbereitungstechnik, 6th year of publ., Issue 5, pp. 271 -- 278. 1965.

Knoll, E. Planung der Mullverbrennungs- und Müllsinterungsanlage Berlin-Ruhleben (Planning the Waste Incineration and Waste Sintering Plant Berlin-Ruhleben). — Mitteilung des VGB Issue 96, pp. 220—223. June 1965.

Boie, W. Beiträge zum feuerungstechnischen Rechnen (Contributions to Technical Calculations Concerned with Incineration). — Wissenschaftliche Zeitschrift der TH-Dresden, 2, Issue 415. 1952/53

Tanner, R. and R. Bopp. Die Technik der Mullverbrennung (The Technique of Waste Incineration). — Separatauszug aus PRO AQUA 1965. Verlag A. Grob AG. St. Gallen.

CONCEPT AND DESIGN OF THE JOINT U.S. PUBLIC HEALTH SERVICE-TENNESSEE VALLEY AUTHORITY COMPOSTING PROJECT, JOHNSON CITY, TENNESSEE[*]

By John S. Wiley,[**] *F. E. Gartrell,*[†] *and H. Gray Smith*[††]

About 25 years ago Europeans, led by the Dutch, began development of modern composting plants for the disposal and utilization of urban solid wastes. At first the objective was to produce compost for use as a solid builder or conditioner; later, the objective was primarily to provide a sanitary method of waste disposal and secondarily to utilize the resulting compost. While there were many composting processes, two types of plants predominated: the rasping system-windrow composting plants developed by the Dutch N.V. Vuilafvoer Maatschappij (VAM) and the Dano biostabilizer plants developed by the Dano Works in Denmark.

In the United States, Waksman and his associates conducted research from 1926 to 1941 on aerobic decomposition of plant residues and manures. The first basic studies on aerobic composting of community solid wastes were conducted by the University of California, Sanitary Engineering Research Project[1], during the period 1950 to 1952. One conclusion of this work was that composting should be considered as a means of disposal and reclamation for municipal refuse. Gotaas[2] later prepared a comprehensive text on this subject for the World Health Organization.

From 1953 to 1962 Wiley and others of the Public Health Service, Communicable Disease Center, conducted laboratory studies at Savannah, Georgia, and pilot plant studies at Chandler, Arizona. These studies indicated that composting of municipal refuse, with or without sewage sludge, is a feasible and sanitary method of treatment. However, at that time funds were not available for large-scale municipal demonstrations.

At about the same time, Gartrell first proposed a full-scale composting project to be jointly sponsored by the Tennessee Valley Authority (TVA), the Public Health Service (PHS), and a municipality in the Tennessee Valley area. Both TVA and PHS are interested in sanitary methods of disposal of municipal solid wastes without creating problems of health hazards, nuisance, and water, land, or air pollution. Composting appeared to present a satisfactory method of waste disposal and at the same time to produce a marketable material useful in soil improvement. Marketability of the compost produced greatly affects the economy of a composting operation and may determine whether the process is competitive with other sanitary methods of solid waste disposal.

TVA operates the National Fertilizer Development Center at Muscle Shoals, Alabama, one of the world's largest fertilizer research and development institutions. As a part of its agricultural research and development program, TVA has resources to test and demonstrate the value of compost as a soil amendment and to study marketing opportunities. While the nutrient contents of compost, nitrogen, phosphate, and potash (N, P_2O_5, K_2O) are relatively low, tests may reveal benefits from fortifying compost with nutrients to produce an organic-base fertilizer.

Most American composting plants built in recent years have relied on the sale of compost and salvaged materials for their primary income, while there was only a nominal payment by the municipality for disposal. Wiley and Kochtitzky[5] concluded that the inability to dispose of large quantities of compost at a favorable price was probably a major factor in the closing of six of nine plants during the period 1962 to 1964. Nevertheless, interest in composting is increasing, and half a dozen plants have recently been completed or are under construction. There will be 9 distinct composting processes represented in the 15 American plants, each undergoing modification and improvement. Reliable cost data are not available, but the industry has found it necessary at the newer plants to increase charges for disposal and to place less reliance on income from sales of compost to meet processing costs.

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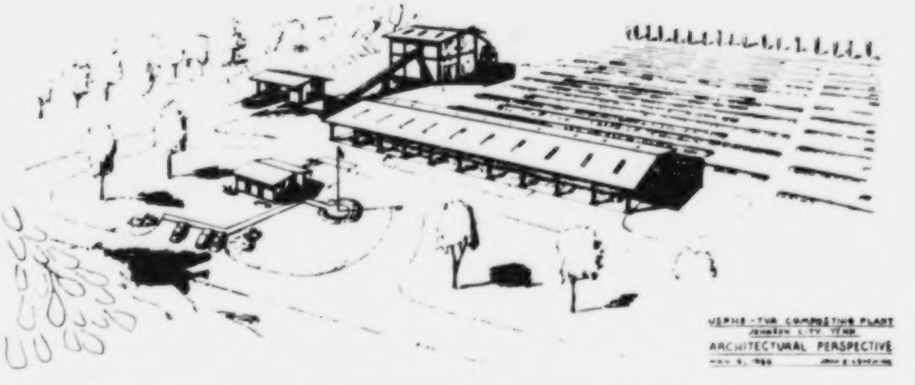
Processing raw sewage sludge with solid wastes at a composting plant rather than at the sewage treatment plant should greatly improve the economics of composting. Normal sludge digestion and air drying account for an appreciable portion of the cost of waste-water treatment and produce only a low-value product that may contain pathogens and undesirable viable seeds. Since moisture must be added to mixed refuse for optimum composting, sludge can be used to provide moisture along with other benefits. The nutrients in raw sludge will enhance the decomposition of refuse and augment both structure and nutrient content of the compost. Sludge thickening is required, however, when all sludge and refuse from the same contributory population are combined. There are several relatively inexpensive means of concentrating or dewatering sewage sludge.

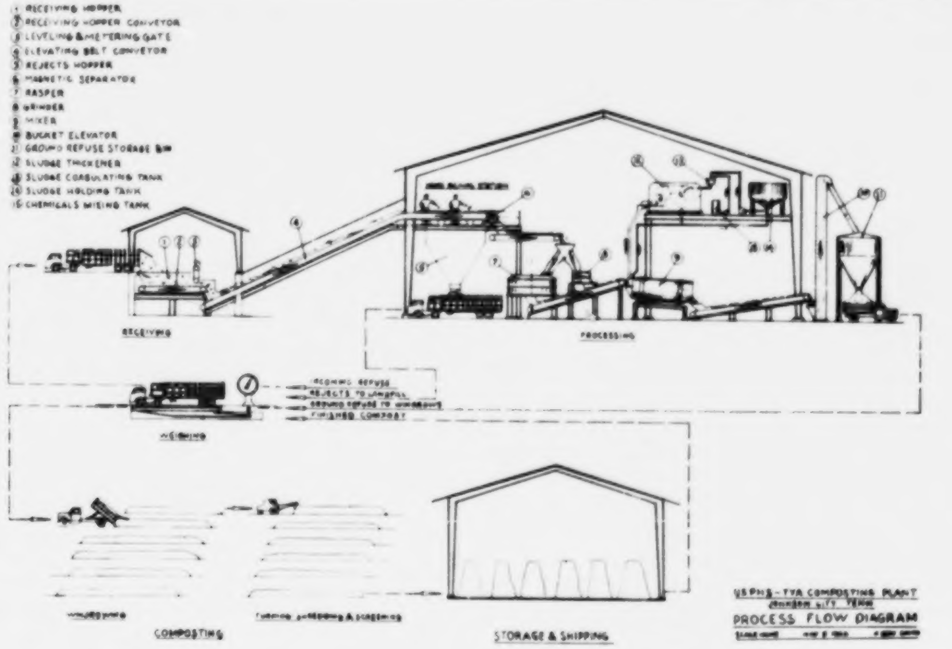
In normal composting, the aerobic thermophilic decomposition produces temperatures of 140°F or higher for several hours or even days. Such a time-temperature factor is believed to be adequate to destroy most, if not all, pathogens. Reports by Knoll[6], Wiley[7], and Krige[8], on European and South African studies have consistently indicated the safety of composts produced by a number of processes. Several reports have indicated that antimicrobial substances are produced during composting and that their action may be as important as time-temperature in destroying pathogens. It appears obvious that compost produced from refuse-sludge mixtures is less apt to contain viable pathogens and seeds than normally digested sewage sludge. However, few studies of these factors have been made in the U. S. A.

PHS is interested in the public health aspects of solid wastes composting and of the use of finished compost in various applications. PHS proposes to study plant operation and sanitation methods to avoid production of odors, propagation of flies and rodents, and disease hazards to the workers and visitors. The Public Health Service also will direct studies on the survival of pathogens and indicator organisms throughout the composting and curing periods. This is particularly important when raw sludge is used in the process.

Implementation of the Project

From 1960 to 1964, Tennessee Valley Authority-Public Health Service conferences were held at Savannah and Atlanta, Georgia; Knoxville, Tennessee; Washington, D. C.; and Muscle Shoals, Alabama. PHS and TVA agreed in August 1964 to undertake a joint research and demonstration project on solid wastes composting. Engineers of TVA, with state and local health department representatives, surveyed refuse and sewage sludge disposal at six cities in the Tennessee Valley area. Agricultural specialists of TVA made surveys of the use of chemical and organic fertilizers in the same six areas. Johnson City, Tennessee, was selected as the preferred site for the proposed research-demonstration composting plant and it agreed to join PHS and TVA in the project.


USPHS - TVA COMPOSTING PLANT
JOHNSON CITY TENN
ARCHITECTURAL PERSPECTIVE
MAY 6, 1966


1 RECEIVING HOPPER
2 RECEIVING HOPPER CONVEYOR
3 LEVELING & METERING GATE
4 ELEVATING BELT CONVEYOR
5 REJECTS HOPPER
6 MAGNETIC SEPARATOR
7 RASPER
8 GRINDER
9 MIXER
10 BUCKET ELEVATOR
11 GROUND REFUSE STORAGE BIN
12 SLUDGE THICKENER
13 SLUDGE COAGULATING TANK
14 SLUDGE HOLDING TANK
15 CHEMICALS MIXING TANK
RECEIVING
PROCESSING
INCOMING REFUSE
REJECTS TO LANDFILL
GROUND REFUSE TO WINDROWS
FINISHED COMPOST
WEIGHING
WINDROWING
COMPOSTING
TURNING, GRINDING & SCREENING
STORAGE & SHIPPING
USPHS - TVA COMPOSTING PLANT
JOHNSON CITY TENN
PROCESS FLOW DIAGRAM

In March 1963 the TVA Division of Agricultural Development initiated a project on "The Use of Municipal and Industrial Organic Wastes in the Production of Soil Amendments and Fertilizers." A continuing study of the disposal of organic municipal and industrial wastes as soil amendments consists of surveys in various sections of the United States to determine the scope and nature of the problem and the current status of research and development in this field. Studies are being conducted on economical means of converting composts into forms suitable for large-scale disposal and to determine the agronomic values of such products. TVA will conduct experiments on the preparation of acceptable composted products, in testing and demonstrating their value and effect, and in determining the market potential for various uses, directed specifically to the operation of the demonstration plant after its completion.

Wiley was transferred in November 1964 to the TVA Division of Health and Safety in Chattanooga to collaborate with TVA in detailed planning of the project. Later, he will move to Johnson City to provide technical guidance in plant operation and to coordinate research activities. A cooperative project agreement on the "Joint U.S. Public Health Service-Tennessee Valley Authority Composting Project, Johnson City, Tennessee," was signed on February 15, 1966, by representatives of the two Federal agencies and Johnson City. Under the agreement TVA will design, construct and operate the plant with technical guidance from the PHS and will be reimbursed by PHS for expenses of the project. The city will be reimbursed for services and expenses above normal as a result of the operation of the research-demonstration composting project.

Compost Plant Design

The composting plant will be constructed on a site provided by Johnson City adjacent to its sewage treatment plant. The compost plant will be of the windrow type capable of treating all mixed refuse and raw sewage sludge from the city of 33,000 population. Certain commercial and industrial organic wastes also may be treated. The plant is designed to operate 5.5 days per week, with a single shift, and is expected to process an average of 58.5 tons per day of mixed refuse with a maximum of 70 tons per day and sludge quantities of 9,100 to 13,200 gallons per day (five % solids) or 3,800 to 5,500 pounds per day of dry sludge solids. Refuse processing equipment is designed to handle 10 tons per hour.

The accompanying flow diagram and the view on the cover show the processing steps and layout of the plant. Refuse will be delivered to the plant in 53-cubic-yard compaction trailers. All incoming refuse, discarded wastes, and compost will be weighed on truck scales adjacent to the office and laboratory building. The receiving hopper has a capacity of about 3,500 cubit feet or about one-half day's collection. A 6-foot-wide plate conveyor, moving about a foot per minute, carries the refuse past a vertical leveler and drops it onto a 3-foot-wide elevating and sorting belt conveyor traveling at right angles to the plate conveyor. The receiving building will be roofed and enclosed on three sides. The belt conveyor will be enclosed between receiving and processing buildings.

The processing building will be 40 feet by 60 feet in plan and will house all of the refuse processing operations, the sludge thickener, and the refuse-sludge mixer. Bulky paper, rags, metals, glass, and other noncompostable material, about 25 percent of the incoming refuse, will be removed by hand sorting and magnetic separation and hauled to the Johnson City sanitary landfill for disposal. Two types of grinders, a rasping machine and a hammermill, each with a design capacity of about 8 tons per hour, are so placed that they can be used alternatively for comparison of efficiency and costs of operation and maintenance. The refuse of about

35 percent moisture content, after sorting and grinding, will be mixed with thickened sludge and water as needed to increase moisture to 50 to 60 percent for the windrow composting.

Initially digested sludge will be pumped from one of the two digesters for thickening and composting with the refuse. As more sludge is removed than received, the digesters gradually will be converted to concentrating tanks until essentially raw sludge is being pumped. Sludge will be thickened in a Permutit DCG Solids Concentrator to a moisture content of about 85 to 88 percent. Filtrate from the sludge thickener, along with wastewater from the compost plant, will be returned to the sewage treatment plant for processing.

The refuse-sludge mixture will be composted on a 5-acre area graded and stabilized with crushed rock. Windrows, deposited by dump truck, will be about 7 feet wide by 5 feet high and up to 230 feet long. The active composting time in windrows will be 30 to 35 days with a maximum of 44 days. During this time the refuse-sludge mixture will be turned 5 to 10 times with a self-propelled loader. To maintain 50 to 60 percent moisture content in the composting mixture, water will be added as needed during the turning operation.

As the compost is loaded for transfer to the storage shed, it is planned to use a portable shredder and rotary screen unit. The storage shed will be 60 feet by 200 feet in plan and will provide shelter for curing, air drying, and storing the compost. After composting, at least two weeks of curing in windrows will be provided during which the moisture content of the compost is expected to drop to about 25 percent. The estimated average daily production of compost is about 25 tons or 42 percent of the weight of incoming refuse.

Plant Operation and Research Studies

The plant operation will be completely coordinated with municipal activities concerned with refuse collection and disposal and sewage treatment. The city will maintain its present sanitary landfill and sewage sludge treatment facilities for use as needed.

The full-scale plant is planned to demonstrate a windrow method of composting solid wastes which may have application for other communities of possibly 100,000 population or less. One of the objectives of the project is to study the economics of the process. Complete construction and operating cost data will be obtained and economic evaluation of the process will be made. Various methods of "cleaning up" the compost will be tried to remove bits of glass, metal, stones, rubber, leather, plastics, and similar noncompostable materials. Processing methods and duration of composting and curing will be varied with the findings of the two major research studies: pathogen survival in the compost and market uses and value of the product in an effort to speed up decomposition and thus reduce operating costs.

Based on the pilot-plant studies by the Public Health Service at Chandler, Arizona, it is expected that 30-day windrow composting will decompose 35 to 40 percent of the volatile solids. During this time the peak temperature at 10-inch depth in the windrow is expected to be 160 to 168°F and a temperature of 150°F or more will be maintained for 16 to 22 days. However, temperatures in the outer and bottom layers (possibly 2 to 4 inches thick) are expected to be less than 140°F most of the time.

Routine analyses will be made on samples of raw wastes and compost for total solids, volatile solids, moisture, and pH. These measurements will serve both in plant control and in plant performance studies. Temperature, moisture, oxygen, and pH measurements will be taken routinely in the composting windrows so that turning schedules and moisture additions may be regulated. Multipoint temperature recording will be employed in an attempt to correlate time-temperature with pathogen destruction.

Certain chemical tests, principally for nitrogen, phosphate, and potash, will be performed periodically to assess the nutrient value of the compost. The value off high nutrient wastes and of chemical fertilizer materials added to the composting mixture will be determined as they affect both the composting process and the nutrient value of the final compost. Small special windrows of different mixtures of wastes will be prepared and tested in connection with both the pathogen survival studies and the studies on market evaluation of the compost.

To detect and permit the correction of any health or safety hazards or nuisance conditions, close observations of odors, dust, noise, flies, and rodents will be made throughout the plant. The extensive studies of pathogen survival probably will be conducted under a PHS contract with an educational institution starting soon after plant completion next spring. These studies will involve the direct enumeration of those indicator organisms and pathogens normally occurring in refuse and sludge, in the raw wastes and after various periods of decomposition in the composting and curing processes. Selected pathogens, not normally occurring in measurable numbers in the raw wastes, will be inserted in the windrows in porous containers for determination of survival rates. Microorganisms will include vegetative and spore-forming bacteria, fungi, protozoa, viruses, and helminths, including some of the most resistant pathogens.

The agronomic studies of compost conducted by TVA will include greenhouse experiments and test demonstrations in plots of the application of compost for various purposes, and the development of marketing potentials for the compost. Tests will be conducted on bare areas such as highway cuts and strip mine spoil banks to assess the value of compost in preventing soil erosion and aiding revegetation on such slopes.

While the principal use of compost is expected to be as a soil builder or conditioner, tests also will be made with compost fortified with nutrients to create an organic-base fertilizer. Large-scale use of compost on farm and pasture land is not anticipated, but appreciable applications on gardens, parks, lawns, golf courses, and truck or specialty farms may be potential outlets. Other uses will be sought, such as compost utilization as poultry litter.

The demonstration composting plant operation is scheduled to continue through fiscal year 1972.

Bibliography

Reclamation of Municipal Refuse by Composting. — Technical Bulletin No. 9. Sanitary Engineering Research Projects, University of California, p. 89. Richmond, California, 1953.

Gotaas, H.B. Composting: Sanitary Disposal and Reclamation of Organic Wastes. — Monograph No. 31. Geneva, World Health Organization, 1956. New York, Columbia University Press International Documents Service, p. 205.

Wiley, J.S. and G.W. Pearce. A Preliminary Study of High-rate Composting. — Paper 846. In Transactions, American Society of Civil Engineers, Vol. 81. Dec. 1955.

Wiley, J.S. and J.T. Spillane. Refuse Sludge Composting in Windrows and Bins. — In Proceedings, American Society of Civil Engineers, Paper 2941. Journal of the Sanitary Engineering Division, 87 (SA5), pp. 33—52. Sept. 1961.

Wiley, J.S. and O.W. Kochtitzky. Composting Developments in the United States. — Compost Science, 6 (2), pp. 5 — 9. Summer 1965.

Knoll, H.H. Public Health and Refuse Disposal. — Compost Science, 2 (1), pp. 35 — 40. Spring 1961.

Wiley, J.S. Pathogen Survival in Composting Municipal Wastes. — Journal of the Waste Pollution Control Federation, 34 (1), pp. 80 — 90. Jan. 1962.

Krige, P.R. The Utilization of Municipal Wastes. — Report No. 211. Pretoria, South African Council for Scientific and Industrial Research. 1964.

MELTING METHOD FOR MONITORING TEMPERATURE IN COMPOSTING WINDROWS

By F. Moller and K. Krannich, Bezirks-Hygiene Institut, Potsdam (Director: Senior Medical Councillor Dr. F. Kohler)

When solid municipal wastes are composted, a check should be made, on principle, on the observance of certain conditions of disinfection. A check is indispensable at least in the processing of such hygienically suspicious initial materials as sewage sludge, night soil, animal feces, slaughter waste, and similar waste. In the interest of comprehensive prophylaxis, the safe destruction of these wastes enriched with microbic and parasitic pathogens, must be ensured during the curing process. This disinfection control can be carried out best by temperature monitoring, because the disinfection factor is of decisive, though not exclusive, importance in making hygienic the raw materials.

Continuous monitoring of the temperature requires a simple method, needing only cheap and sturdy apparatus, and must not be time-consuming. A method fulfilling these requirements is melting, as described below.

Description of the Method

When the composting windrow is piled up, certain organic substances with specific melting points are introduced. Daily or at intervals of several days, checks are made to ascertain which substances have melted, which substances are still in the solid state, and which have resolidified.

We use industrial paraffins and waxes with melting points between 43 and 75°C. The test substances are sealed in ampoules made of commercial test tubes, the ampoules are fixed with two rubber rings on an ampoule holder which then is slipped into a guide tube and placed into the windrow (Figures 1 and 2).

Polythene, which retains its shape in temperatures up to 80°C, proved suitable for ampoule holders and guide tubes. The tube is closed by a tightly fitting rubber lid to which the ampoule holder is fixed with a perlon string. Felt disks at the upper and the lower ends of the ampoule holder prevent temperature compensation by convection in the guide tube. Lengths of tube and string are selected to correspond to the depth of the measuring point in the windrow. One tube may contain several ampoule holders, connected with each other, if the temperatures are to be monitored at several levels inside the windrow.

The melting method makes it possible to prove when the windrow temperature exceeds certain boundary points, corresponding to the melting points of the test

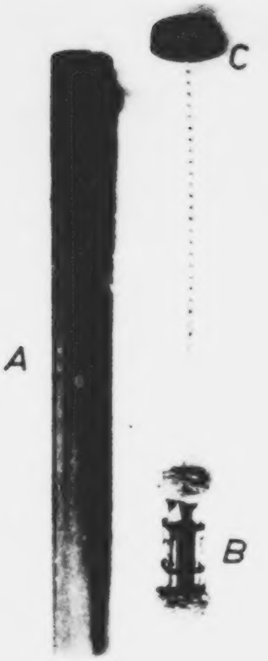


FIGURE 1. Device for temperature monitoring by the melting method:
A = guide tube; B = ready ampoule holder with four sealed glass ampoules containing the test substances; C = cap

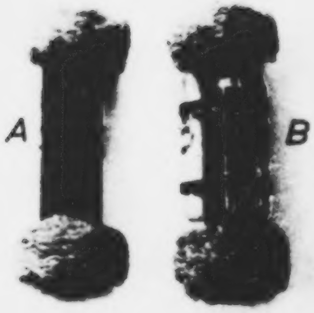


FIGURE 2. Ampoule holder, grooved longitudinally (A).
The ampoules, placed into the grooves, are held by two rubber rings (B).

substances, and how long the temperature remains above the boundary value. How many and which test substances are to be used, has to be decided according to the actual task. In the simplest case, a substance suffices if its melting point is identical with the boundary inactivation temperature.

After the windrows have been piled, the ampoules are checked daily. Ampoules with melted contents are removed from the ampoule holder, the substance is left to solidify in air, and is then reinserted in such a way that the ampoule's filled end points upward. If that substance with a melting point corresponding to the stipulated boundary inactivation temperature is found to be liquid, checks are necessary only once in two or three days until the end of the planned inactivation period. After that, checking may cease altogether.

According to our experience gained earlier, three check points per windrow, each windrow being up to 50 m long, are sufficient to yield reliable information on the course of the temperature.

Discussion

In investigations on compost models, remote thermometers were used successfully. Advantages of this method of measuring temperatures are: independence of the measuring and indication units, and the possibility of recording the measured values, if required, by temperature recorder. However, the method will be hardly suitable for current production control because of the high investment costs and the susceptibility of the apparatus to breakdown. When temperatures are monitored by liquid-column thermometers, a high rate of wear and tear, owing to breakage and corrosion, must be expected, so that this method is very costly also.

The melting method of monitoring temperatures in plant control is cheap and requires little maintenance. Cost of the materials required is lower than that of the cheapest windrow thermometers. With little labor, the user himself can construct the equipment. During the half year of experimental operation no corrosion damage occurred.

Jansen and Kunst (1953) found the maximum decay temperatures in a melting test with organic compounds which had been kept in ampoules and were buried in windrows. For assessing the disinfection effect, however, the maximum temperature is not so interesting; it is more important whether the thermal disinfection condition (boundary inactivation temperature and minimum duration of its effect) was fulfilled (Burger 1965, Knoll 1961, Strauch 1964). The melting method can safely prove that such a condition of disinfection has been fulfilled (Figure 3).

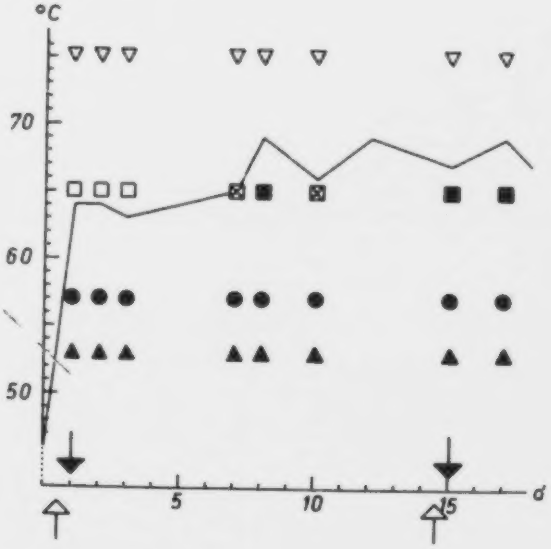


FIGURE 3. Proof of fulfilment of thermal disinfection condition in a windrow for composting refuse sewage sludge, after Knoll (1961). Position of measuring point: 0.33 m below windrow crest. Comparison of results by melting method (symbols) and temperature measurements with maximum thermometer (graph). White symbol: test substance solid. Black symbol: test substance liquid. Crossed symbol: test substance partially liquid. Boundaries of the period in which thermal disinfection condition, after Knoll (1961), was fulfilled: according to results of melting method by black arrows, according to temperature measurement by thermometer by white arrows.

Acknowledgements

Thanks for suggestions concerning the elaboration of the method are due to Dr. Burger, Dresden; Professor Dr. Hirsch, Dresden; and Mr. Geissler, Wassmannsdorf. We also wish to express our thanks to VEB [national corporation] Hydrierwerk Zeitz, VEB Montanwachsfabrik Volpke, and VEB Paraffinwerk Webau for letting us have samples of materials.

Bibliography

Burger, G. Moglichkeiten und Grenzen der Entseuchung infektioser Siedlungsabfalle auf dem Wege der aeroben Kompostierung (Possibilities and Limitations of Disinfection of Infectious Municipal Waste by Aerobic Composting). – Zeitschrift ges. Hyg., Vol. 11, pp. 409 – 422. 1965.

Jansen, J. and H Kunst. Are pathogenic microorganisms killed in waste-dumps where sufficiently high temperatures occur?. – Netherl. Journ. Agricult., Vol. 1, pp. 111 – 114. 1953.

Knoll, K.H. Die Anforderungen der Hygiene bei der Beseitigung stadtischer Abfallstoffe (Hygiene Requirements in the Disposal of Urban Waste). – Städtehygiene. Vol. 12, pp. 95 – 99. 1961.

Strauch, D. Veterinarhygienische Untersuchungen bei der Verwertung fester und flussiger Siedlungsabfalle (Veterinary-Hygienic Examinations Accompanying the Utilization of Solid and Liquid Municipal Waste). – Schriftenr. Geb. öffentl. Gesundheitsw, Issue 18. 1964.

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COMMUNICATIONS FROM INDUSTRY

Development of the Dano waste disposal process

For 25 years a department of the engineering works Dano in Copenhagen has dealt theoretically and practically (100 plants) with waste disposal. Here we want to provide a survey of the operational results of these plants and of the experience gained in the utilization of compost produced from waste.

Because the composition of the waste (refuse and bulky material) is subject to extraordinarily large local and temporal fluctuations, it is difficult to establish generally valid rules. Fortunately, development everywhere exhibits similar features. The advent of affluence, the ascendent role of mineral oil, and the changes in living habits did not occur everywhere simultaneously, but by and large they did occur everywhere.

These factors greatly affect the amount and composition of the waste, which in its turn is decisive for the selection of the disposal method. Unfortunately, in actual practice, the system frequently is selected first on the basis of more or less substantiated prejudices, and experience is accumulated only afterwards. The reason for this rather irrational approach probably lies in the difficulties connected with preliminary investigations of the nonhomogeneous material. This difficulty should not be overestimated, however, for even an accurate determination of weights, which practically costs nothing, constitutes a great advantage for sensible planning. The determination of the main components: kitchen refuse, paper and board, ash, bulky objects, metals, and sewage sludge, or chemical analysis of water, combustibles and noncombustibles is somewhat more difficult, but still can be carried out fairly simply in random tests.

A useful guideline can be obtained from statistical investigations concerning the consumption of various groups of commodities such as vegetables and southern fruits, meat, fish, poultry, paper and board, plastics, etc. The proportion of these groups of commodities in waste and bulky materials can be easily found. Such calculations agree very well with the analyses carried out by hand sorting; they show that nowadays about 80% of the waste can be composted. If sewage sludge is taken into account, the percentage is even higher.

The amount of plastics, though increased, still constitutes only a small percentage of waste. This also is true of such bulky components as pieces of furniture of all kinds, bicycles, and old cars. Their disposal is an esthetic, not a hygienic, problem which has to be solved separately.

On the other hand, disposal of paper and cartons is a central problem. Dano, therefore, made a more thorough investigation of the biological decomposition of cellulose. Different kinds of paper decompose at a different rate, but they all decompose comparatively easily and yield an excellent compost.

Another feature of present-day waste, the small ash content, is also an advantage in reference to compost quality. Nowadays, compost is of considerably better quality than it was in the past.

The Dano plants adapted to the new facts. The principle of Dano consists in spontaneous grinding of waste in horizontal rotating drums, partly equipped with grinding and screening chambers. Based on this principle, machines for different purposes were developed: on the one hand, simple and cheap plants for bulk reduction, where fines are screened off only in an amount necessary for covering a dump; on the other hand, plants which produce as much compost as possible of the highest possible quality.

Unlike other methods, Dano grinding consists in simultaneous mixing and continuous internal friction of the material. This is particularly advantageous for paper and carton because they dissolve completely under the action of moisture (possibly with the addition of sewage sludge) and friction. Comparatively small driving force is needed during prolonged periods, and comminution and bulk reduction is attained with little power and wear of the machinery.

The most important machines developed on this basic principle are: the Dano-Egsetor, the Dano-Rotating Drum, and the Dano-Stabilizer.

The Dano-Egsetor consists of a grinding chamber and a coaxial screen rotating with it but outside it. From the grinding chamber, the material moves to the screen, from where the rejects return to the grinding chamber. Thus the Dano-Egsetor screens, in addition to mixing and reducing the bulk. Depending on the material and the work program, more or less fines and the corresponding amount of screen rejects can be produced continuously or discontinously. The Dano-Egsetor is particularly suitable for waste of great specific weight. If the proportion of paper is large and, correspondingly, the bulk weight small, the output is reduced.

Because of this, a rotating drum is often placed before the Egsetor, so that the material can be treated more rapidly in the Egsetor after the bulk has been reduced. The newest plant of this type is now being built for the town of Izmir in Turkey.

The Dano-Rotating Drum consists of a horizontal rotating drum with baffles, knives, and input and output faces. A high degree of filling, which permits correspondingly long and effective treatment, can be attained only with a stationary face of special design (Dano patent).

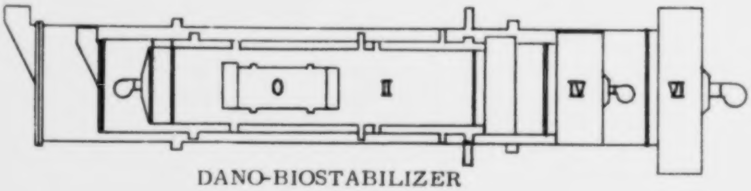
The Dano-Rotating Drum causes high bulk reduction, especially when the material contains paper. The material can be dumped as obtained or after screening, whereby sufficient fines are obtained for coverage.

Accurate cost analysis shows that simple treatment in a Dano-Rotating Drum is frequently cheaper than so-called controlled tipping. Really controlled tipping is very rarely carried out as theoretically required. Also it is possible only if the landfill is not made in high layers, and if these are immediately covered. The advantages of the Dano-Rotating Drum process for controlled tipping are

1. The refuse trucks drive on a hard road to a dumping bunker and not over the landfill.
2. There is no need for covering soil which fills up the tipping site prematurely; yet, progressive planting on the site is possible.
3. No dust and fluttering paper, no fires, and no rats and birds defile the environment.
4. Addition of sewage sludge for processing is possible.

The grinding efficiency of the rotating drum can be assessed from screen analyses of the treated materials. The more fines obtained, the better the efficiency. Actual practice showed that long treatment, such as occurs over the week-end for instance, leads to a temperature rise on one hand, with a considerably increased grinding action, on the other hand.

Since the Dano laboratory at the same time carried out investigations concerned with transformation of material and energy during aerobic digestion, aerating the rotating drum was a fairly obvious idea. Aeration gave a strong effect: the temperature rose higher and more rapidly. After aeration of the Dano-Rotating Drum had been introduced, and the time of treatment was extended from 8–16 hours to several days, the Dano-Biostabilizer was developed. This equipment proved particularly suitable for present-day waste.



DANO-BIOSTABILIZER

The illustration shows the growth of the Dano-Biostabilizers. The experimental model 0 (about 1,000 inhabitants or 300 tons/year) was built in 1951, followed by sizes II, IV and VI in 1954, 1956 and 1958, respectively.

In a continuation, we shall describe experience with the Dano-Biostabilizer, and discuss the quality and application of the compost.

LITERATURE RECEIVED BY THE SECRETARIAT

Albinus, G. Kritische Betrachtungen über die Mullverbrennung in kleineren Anlagen (Critical Considerations Concerning Waste Incineration in Small Plants). – Technische Ueberwachung, Vol. 7, No. 12, Essen. 1966.

Barton, A. E. Les travaux d'assainissement de la ville de Fribourg; traitement des eaux usées et des résidus. – Bulletin No. 18 de l'Association Romande pour la protection des eaux et de l'air, ARPEA, Genève. 1967.

Bopp, R. Anfall und Vernichtung von Oelabfallen (Occurrence and Destruction of Oil Wastes). – Schweiz. Bauzeitung, 85th year of publ., Issue 9. 1967.

Braun, R. Stand der Abfallbeseitigung in der Schweiz (State of Waste Disposal in Switzerland). – Wasser- und Energiewirtschaft, 59th year of publ., No. 2. 1967.

Brugger, G. Die Aufbereitung von stadtischen Siedlungsabfallen und ihre Verwendung im Weinbau (Processing Urban Residential Wastes and Their Utilization in Vine-Growing). – Rebe und Wein, Weinbau-Fachzeitschrift für Baden-Wurttemberg und Franken, Jahrbuch-Verlag, 7102 Weinsberg. 1966.

Busse, G. Ist die Schlammfaulung noch zeitgemäss? (Is Sludge Digestion Still Modern?). – Korrespondenz Abwasser, No. 9, Bonn. 1966.

Busse, G. Die Entwasserung von Abwasserschlämmen in Filterpressen unter besonderer Berucksichtigung der Schlammaufbereitung (Dewatering of Sewage Sludge in Filter Presses with Special Consideration of Sludge Processing). – Kommunalwirtschaft, Issue 9. 1966.

De la Rubia Pacheco, J. "Manufacturing" Compost from Urban Refuse in Spain. – Compost Science, Autumn, Vol. 7, No. 2. 1966.

Deutscher Weinbauverband e.V. Richtlinien für die Anwendung von Mull- und Mullklarschlamm-Komposten im Weinbau (Guidelines for Application in Vine-Growing of Compost from Waste and Sewage Sludge). – Deutscher Weinbauverband e. V., 63 Bonn, Heussallee 26. 1966.

Doherty, R.M. What's Involved in a Solid Waste Program?. – Compost Science, Autumn, Vol. 7, No. 2. 1966.

Eby, H. J. Two Billion Tons of - What!. – Compost Science, Autumn, Vol. 7, No. 2. 1966.

Eckart, J. Müllabfuhr mit Grossbehaltern (Garbage Disposal with Large Bins). – Die örtliche Versorgungswirtschaft, Issue 5, 2nd year of publ., Dresden. 1966.

Einenkel, E. Maschinen in der Mietenkompostierung (Machines in Windrow Composting). – Die ortliche Versorgungswirtschaft, Issue 5, 2nd year of publ., Dresden. 1966.

Erhard, H. Gedanken über Leistungen in der Müllabfuhr (Thoughts Concerning Performance in Garbage Disposal). – Der Stadtetag, Issue 11. 1966.

Gelsdorf, G. Baumassen in Mullverbrennungsanlagen (Building Masses in Waste Incineration Plants). – Mull-Abfall-Abwasser, Issue 2, Verl. A. Schweiger, Duren. 1966.

Gockel, H. Spaltung und Entgiftung von Oelemulsionen und synthetischen Schleifmitteln unter den Gesichtspunkten des Wasserhaushaltgesetzes (Splitting and Detoxication of Oil Emulsions and Synthetic Grinding Agents Under the Aspects of the Water Economy Law). – Mineralol, Zeitschr. f. Mineralolwirtschaft, Issue 11. 1966.

Gockel, H. Die Entgiftung von Cyanid, Barium, Nitrit und olhaltigen Abwassern sowie Restkonzentraten aus Hartereien (Detoxication of Cyanide, Barium, Nitrite, and Oil-Containing Sewage as Well as Residual Concentrates from Hardening Shops). – Mineralol, Zeitschr. f. Mineralolwirtschaft, Issue 11. 1966.

Gothard, S. A. The International Picture of Refuse Disposal. – Compost Science, Autumn, Vol. 7, No. 2. 1966.

Heer, H. Entstauber hinter Mullverbrennungsanlagen (Dust Collector Behind Waste Incineration Plants). – Mull-Abfall-Abwasser, Issue 2, Verlag A. Schweiger, Duren. 1966.

Hein, H. Die Sperrmullverbrennungsanlage der Stadt Braunschweig (The Bulky-Refuse Incineration Plant of the Town of Braunschweig). – Mull-Abfall-Abwasser, Issue 2, Verlag A. Schweiger, Duren. 1966.

Hempel, G. Rationalisierung der Mullabfuhr und ortliche Organe (Rationalization of Garbage Disposal and Local Authorities). – Die ortliche Versorgungswirtschaft, Issue 1, Dresden. 1967.

Hermes, P. Mullverbrennungs- und Mullschlackensinteranlage, Berlin-Ruhleben (Waste Incineration and Waste Clinker Sintering Plant, Berlin-Ruhleben). – Der Stadtetag, Issue 10. 1966.

Hirschheydt, v. A. Wie ist das eigentlich genau? Fragen zur Vergleichbarkeit in der Abfallbehandlung (How Is It Exactly? Questions Concerning the Comparability in Waste Treatment). – Stadtereinigung, 3rd year of publ., Issue 4, Vienna. 1966.

Hirschheydt, v. A. Zur Frage der Mull-Kompostierung (On the Question of Composting Waste). – Kommunalwirtschaft, Issue 1, Dusseldorf. 1967.

Hofer, J. F. Erfahrungen mit Abfallverbrennungsanlagen (Experience with Waste Incineration Plants). – Aufbereitungs-Technik, 7th year of publ., Issue 6. 1966.

Horstmann, O. Fragen der Mullkompostierung (Questions of Composting Waste). – Der Stadtetag, Issue 2. 1967.

Jager, B. Gemeinsame Behandlung von Abfallstoffen verschiedener Herkunft (Simultaneous Treatment of Wastes of Different Origin). – Kommunalwirtschaft, Issue 1, Dusseldorf. 1967.

Karnovsky, F. Die Klarschlammverwertung in Munchen (Sewage Sludge Utilization in Munich). – Gas- und Wasserfach, Wasser/Abwasser, 107th year of publ., Issue 34. 1966.

Kaupert, W. Gedanken zur Mullverbrennung (Thoughts Concerning Waste Incineration). – Der Städtetag, Issue 2. 1967.

Kehr, D. and K. A. Mohle. Aerobe oder anaerobe Schlammbehandlung auf Klaranlagen (Aerobic and Anaerobic Sludge Treatment in Sludge Treatment Plants). – Stadtehygiene, Issue 9. 1966.

Keller, P. Abfallbeseitigung: die Bedeutung der Mull-Klarschlammkompostierung im Rahmen der gesamten Abfallbeseitigung (Waste Disposal: Importance of Waste and Sewage Sludge Composting within the Framework of All Waste Disposal). – Neue Zürcher Zeitung, Supplement Technik 8. 2. 1967.

Klotter, H.-E. Ueber die Beseitigung fester Abfallstoffe und von Abwasserschlamm (Removal of Solid Wastes and Sewage Sludge). – Oesterr. Abwasserwirtschaft, 18th year of publ., Issue 9/10, Springer-Verlag, Vienna. 1966.

Kohler, H. G. Die Mullschere im Kraftwerk Essen-Karnap (The Refuse Shears in the Essen-Karnap Power Station). – Der Stadtetag, Issue 11. 1966.

Kreichelt, Th. E. Air Pollution Aspects of TEPEE Burners Used for Disposal of Municipal Refuse. – Public Health Service Publication No. 999-AP-28, U.S. Dep. of Health, Education and Welfare, Cincinnati, Ohio. 1966.

Le Roux van Niekerk and G. Schliemann. Compost Making. – The Deciduous Fruit Grower, National Commercial Printers Ltd., Elsies River, Vol. 16, Part 10. 1966.

Liebmann, H. Strassenreinigung und Abfallbeseitigung in New York (Street Cleaning and Waste Disposal in New York). – Der Städtetag, Issue 12. 1966.

Mahlke, H. Mullbeseitigung - anders gesehen (Waste Disposal - A Different View). – Der Stadtetag, Issue 1. 1966.

Matile, Ph. Grenzen der Kunstdungerwirtschaft (Limits of the Application of Mineral Fertilizers). – Die Tat, No. 249, of 22. 10. 1966, Zurich. 1966.

McCollam, J. G. Refuse Composting in St. Petersburg, Florida. – Compost Science, Autumn, Vol. 7, No. 2. 1966.

Miller, J. R. Soil-Plant Relationships to Consider for Sprinkler Irrigation Systems Used for Waste Disposal. – Compost Science, Autumn, Vol. 7, No. 2. 1966.

Millot L'incinération des ordures ménagères dans la banlieu ouest de Paris. – Techniques et Sciences Municipales, No. 12, Paris. 1966.

Mischerikow, K. Die Aequivalenzkalkulation fur die Ermittlung der Selbstkosten in der Mullabfuhr (Equivalents Calculation for the Determination of Prime Costs in Garbage Removal). – Der Stadtetag, Issue 12. 1966.

Muller, H.-J. Moglichkeiten und Kosten der Mull- und Abfallbeseitigung (Possibilities and Costs of Waste and Garbage Disposal). – Mull-Abfall-Abwasser, Issue 2, Verlag A. Schweiger, Duren. 1966.

Muller, H.-J. Mullverbrennungsanlagen nach dem Baukastensystem (Waste Incineration Plants According to the Sectional System). – Kommunalwirtschaft, Issue 1, Düsseldorf. 1967.

Olds, J. From Moscow to Haarlem via Tanzania. – Compost Science, Autumn, Vol. 7, No. 2. 1966.

Perl, K. Die Planung von Anlagen zur Beseitigung von Siedlungsabfallen (Planning Municipal Waste Disposal Plants). – Der Abendtechniker, July 1966.

Perl, K. Garantievereinbarungen bei Mullverbrennung (Warranty Arrangements in Waste Incineration). – Oesterr. Ingenieur-Zeitschrift, 112th year of publ., Issue 1, Springer Verlag, Vienna. 1967.

Perrin, Ch. Abfallbeseitigung; ein Verfahren zur Beseitigung von Bohr- und Schneideolemulsionen (Waste Disposal; Method of Removing Drilling and Cutting Oil Emulsions). – Neue Zurcher Zeitung, Supplement Technik, 8. 2. 1967.

Rauther, Th. and K.-G. Maurer. Das Kostenproblem der Mullbeseitigung (The Cost Problem in Waste Disposal). – Kommunalwirtschaft, Issue 9. 1966.

Reinhardt, E. Neuzeitliche Mullbeseitigung in Neustadt in Holstein (Modern Waste Disposal in Neustadt in Holstein). – Kommunalwirtschaft, Issue 10. 1966.

Roediger, H. Aerober und anaerober Abbau der organischen Stoffe bei der Abwasserreinigung (Aerobic and Anaerobic Degradation of Organic Substances in Sewage Treatment). – Das Gas- und Wasserfach, Wasser/Abwasser, 107th year of publ., Issue 32. 1966.

Schatz, A. Humus Research - East and West. – Compost Science, Autumn, Vol. 7, No. 2. 1966.

Schmassmann, H. Ursachen, Folgen und Bekampfung von Grundwasserverunreinigungen in der Schweiz (Causes, Consequences, and Control of Groundwater Pollution in Switzerland). – Internationales Jahrbuch Chemische Industrie, Ausg. 1965, Verlag Vogt-Schild AG Solothurn. 1965.

Schmassmann, H. Grundwasserschutzgebiete in der Raumplanung (Areas of Groundwater Protection in Space Planning). – Wasser und Luft in der Raumplanung, PRO AQUA, Basle 1965, Verlag Vogt-Schild AG, Solothurn. 966.

Schmitt-Tegge, J. D. Abfallbeseitigung (Waste Disposal). – Neue Zurcher Zeitung, Supplem. Technik 8. 2. 1967.

Simons, W. Emissionsmessungen an kleinen Mullverbrennungsanlagen (Measurements of Emissions in Small Waste Incineration Plants). – Technische Ueberwachung, Vol. 7, No. 12, Essen. 1966.

Spohn, E. Hat Kompost eine Zukunft? (Has Compost a Future?). – Stadtehygiene, Issue 10. 1966.

Spohn, E. Ist Mullverarbeitung eine kommunale Aufgabe? (Is Waste Processing a Municipal Task?). – Kommunalwirtschaft, Issue 1, Dusseldorf. 1967.

Strauch, D. Fein gesiebt in Rottezelle: Hausabfalle und Klarschlamm in Landau gemeinsam kompostiert (Finely Screened in Digester: Domestic Refuse and Sewage Sludge Composted Together in Landau). – ZfK, Zeitung fur kommunale Wirtschaft, Issue 9, Munchen. 1966.

Stundl, K. Luftreinigung und Abfallbeseitigung - Hauptprobleme der Stadtehygiene (Air Purification and Waste Disposal - the Main Problems of Municipal Hygiene). – Städtereinigung, 3rd year of publ., Issue 4. 1966.

Tope, O. Thema Abfallbeseitigung international (The Subject of Waste Disposal Is International). – Der Stadtetag, Issue 2. 1967.

Triebel, W. Erfahrungen mit der landwirtschaftlichen Klarschlammbeseitigung (Experience with Agricultural Sewage Sludge Disposal). – Korrespondenz Abwasser, No 10, Bonn. 1966.

Turner, W. A. and A. Sowerby. Refuse Disposal with Special References to Composting and Incineration. – The Institute of Public Cleansing, Spring Meeting, 20th March 1964, Middlesbrough. 1964.

Ullmann. Einige Probleme der Sperrmullabfuhr (Some Problems of Bulky Refuse Disposal). – Die ortliche Versorgungswirtschaft, Issue 6, 2nd year of publ., Dresden. 1966.

Wackermann, W. Umbauten an Feuerungen und Abhitzekesseln im Hausmullverbrennungsbetrieb Hamburg (Reconstruction of the Furnaces and Waste Heat Boilers in the Domestic Waste Incineration Plant in Hamburg). – Technische Ueberwachung, Vol. 7, No. 12, Essen. 1966.

Walter, L. Progress in Refuse Incinerators Supplying Power and Light. – Public Cleansing, February 1967, Vol. 57, No. 2, London. 1967.

Wieprich, O. Kleinversuche in biothermischen Rottezellen (Small-Scale Experiments in Biothermic Digesters). – Die ortliche Versorgungswirtschaft, Issue 6, 2nd year of publ., Dresden. 1966.

Wiley, J. S., F. E Gartrell and H Gray Smith. Concept and Design of a 3-Way Composting Project.– Compost Science, Autumn, Vol. 7, No. 2. 1966.

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SPECIAL ISSUE

PASTEURIZATION OF SEWAGE SLUDGE, TAKING INTO ACCOUNT THE SPECIFIC CONDITIONS PREVAILING IN SWITZERLAND

On 1 January, 1967, 208 communal sewage-purification plants were in operation in Switzerland, serving 1,859,000 inhabitants and the population equivalent of industry (PEI). On the same date, 57 plants were under construction for the benefit of 2,366,000 inhabitants and PEI, while 82 projects, for the service of 1,131,000 inhabitants and PEI, were earmarked for construction in the near future.

It is estimated that at the end of 1970, 50–60% of the total population of Switzerland will be served by sewage-purification plants; this, undoubtedly, is a satisfactory achievement. However, these plants are effective only if the end product of sewage purification – the sewage sludge – can be disposed of satisfactorily.

Taking into account that 1 liter of digested sludge (calculated to contain 92% water) is yielded per capita per day, the quantity to be disposed of per year, in 1970, will amount to over one million cubic meters.

The increasing difficulties encountered by our communities in connection with sludge disposal are only too well known. The simplest and cheapest way of removal from urban areas is to dispose the effluent sludge directly in the fields. Even if transport expenses are borne by the community, this manner of disposal is generally more economical than all other procedures of removal and disposal (dewatering, drying, composting, incineration, etc.).

The difficulties arising in certain communities in connection with the disposal of sewage sludge in the fields are due primarily to the Swiss Milk-Supply Regulations, which forbid disposal of sewage sludge in the fields throughout the vegetation period. Milk and veterinary hygienists consider this practice dangerous since sewage sludge, even though digested, may still carry pathogenic agents (primarily Salmonella and worm eggs). The Swiss Milk Commission is prepared to modify the present Milk-Supply Regulations and to allow disposal of pasteurized sewage sludge in pastures throughout the year. The relaxing of these stringent rules will certainly assist some communities in resolving the problem of sewage-sludge disposal.

Since sludge pasteurization has, so far, not been undertaken in Switzerland, the Director of EAWAG, Prof. Dr. O. Jaag, decided to discuss the problem with German specialists at a symposium at EAWAG.

This symposium took place on 19–20 April 1967. As we assume that the problems raised by the removal, and especially the disposal, of fluid sludge in fields are of interest to wide circles (scientific, farming and administrative), we decided to publish the lectures and debates of this symposium in a special issue of our Information Bulletin.

Dr. R. Braun

OPENING ADDRESS

By Prof. Dr. O. Jaag, Director of EAWAG, President of IAM, Zurich

Gentlemen,

I have the honor and pleasure of welcoming you to the symposium of EAWAG on "Sewage sludge pasteurization." Your attendance in such large numbers clearly demonstrates that you agree with us on the pressing need for a thorough discussion of this problem. In fact, disposal of sewage – both fresh and digested – has been causing ever increasing difficulties lately. Gone are the times when the effluent of digested sewage from large plants was simply passed into the fields; the change that has taken place has been caused mainly by the milk industry. Urged by serious hygienic requirements in regard to the disposal of sewage sludge in pastures, this industry imposed increasingly stringent conditions. These led to the enforcement, in 1954, of the Swiss Milk-Supply Regulations, which almost paralyzed this sewage-disposal practice.

Besides being alert to these developments, EAWAG was faced with the task of finding its own solution to this problem, while taking into account the demands of hygiene and epidemiology.

In various countries, and particularly in the German Federal Republic, certain ways have emerged towards a solution, which seem highly promising for us, too. We must, therefore, thoroughly acquaint ourselves with the implications, procedure and, last but not least, the economic consequences, if we are to test these methods within the specific conditions in our country, and adapt them to our needs.

One way that might help rid ourselves of the sewage sludge is **pasteurization.** Since pasteurization plants are already in use, it seemed advisable to consult the experts, with a view to obtaining reliable information about the technique and problems of this procedure, and in the light of this information, to try to find a rational way of sewage-sludge disposal in Switzerland.

To this end we approached three experts: Prof. Dr. Hans Liebmann, Director of the Bavarian Research Institute for Biology, in connection with public health; Dr. Ing. H. Roediger, Stuttgart, and Building Director W. Triebel of the Niersverband, Viersen, in connection with the entire complex of technical and economic problems, as well as with the results obtained, so far, in sewage-sludge pasteurization.

We are deeply indebted to these three gentlemen for their readiness to include this two-day conference in their already crowded program. I should like to thank them in advance for their lectures, which we hope will stimulate constructive discussions.

It was a matter of course for us to arrange this symposium in conjunction with the Federal Bureau for Water Protection, and I am glad to welcome in our midst the Director of the Bureau, Dr. Ing. F. Baldinger, as well as Dr. Müller, and Dr. Ing. Forster.

We are also very pleased to note that Prof. P. Kästli, Director of the Federal Research Institute of the Milk Industry and President of the Swiss Milk Commission, will represent the interests of that particular branch of the economy.

Next, we were anxious to hear the suggestions that professional circles could offer. We therefore informed the Water Protection Bureau of all cantons about this symposium, and we are glad to note that there is keen interest also in this sector. The problem arose whether experts working in engineering firms should be invited to present their questions at this gathering. After earnest consideration it was decided to leave out the private engineering firms from this first preliminary meeting in order to keep the discussion within reasonable limits. However, reports on the activities during these two days will be forwarded to all those interested, in order to coopt all experts in the search for the most suitable solution.

As mentioned in the invitations, the means for arranging this symposium were offered by the Organization for the Advancement of Water Protection in Switzerland. We wish to thank Prof. G. Schnitter and the Swiss School Council for putting this hall at our disposal. With the construction work of the ETH main building now in progress, and the summer semester having begun, it was rather difficult to find a suitable place for two days.

Now let us hope that in the discussions to follow a basis will be found for further deliberations and for our work in future.

HYGIENIC REQUIREMENTS FOR SLUDGE PASTEURIZATION AND ITS CONTROL IN PRACTICE

By Prof. Dr. H. Liebmann, Director of the
Bayerische Biologische Versuchsanstalt,

The history of sewage purification is the history of the battle fought by hygienists against disease agencies in sewage. It should be emphasized, once again, that installation of sewage plants is a primary condition of hygiene; the health problems involved concern human and veterinary medicine in equal measure.

Taking into account the present level of technical knowledge, we may safely state that installation of a central collector, laying of main sewers for local canalization, and construction of sewage works no longer present a major problem insofar as domestic waste is concerned. While mechanical and biological purification of domestic waste has been achieved, disposal of the sewage sludge remains a problem still to be solved (Liebmann, 1966).

In human and veterinary hygiene there are four groups of pathogens that can be disseminated by sewage or sewage sludge: viruses, bacteria, cysts and oocysts of protozoa, and worm eggs. It is to be expected that of the organisms mentioned those which, in the course of their life cycle, produce resistant forms are the most difficult to be eliminated because in this stage they do not respond to the usual control measures. Therefore, treatment of sewage with gaseous or liquid chemicals for the purpose of destroying these resistant forms has failed. Viruses, known to be devoid of resistant forms, are relatively easily eliminated from sewage. The same applies to bacteria that produce only vegetative forms, but not to sporogenes. Resistant forms of protozoa and worm eggs behave like spores.

During the past 50 years it was repeatedly assumed that spores, resistant forms of protozoa, and worm eggs could be annihilated by appropriate chemical means, such as chlorination, or hyper chlorination. It has been established, however, that this is impossible (Liebmann, 1960).

Since we are dealing with the specific conditions prevailing in Central Europe, we may ignore the protozoa, which should be considered as pathogens of man and animals, disseminated by sewage, in subtropical and tropical areas only (Liebmann, 1964/1).

The diseases frequently disseminated by waters, sewage and sewage sludge in Central Europe are the following:

1. Among the human population: typhoid, paratyphoid, enteritis, tuberculosis, anthrax, poliomyelitis, hepatitis epidemica, Weil's disease and leptospirosis, various helminthic infections, especially with Ascaris lumbricoides and Taenia saginata.
2. Among animals: tuberculosis, salmonellosis, anthrax, foot and mouth disease and fowl pest, and many helminthic infections (Liebmann, 1953).

Of the pathogenic resistant forms, worm eggs are, by nature, excellently protected against environmental effects: they are impervious to any physical treatment (within reasonable economic limits).

Elimination of the vegetative stages of the aforementioned disease agencies is relatively simple, whereas elimination of resistant forms is most difficult. Development of the resistant stages generally depends upon three factors: a certain temperature, humidity and oxygen. The required warmth is evidently present in sewage, and so is the humidity, but free oxygen may be lacking. As a rule, the pathogens are not destroyed in a transient anaerobic phase in which the medium is deprived of the access to free oxygen, nor when the free oxygen disappears with the transition from aerobic to anaerobic conditions.

Although gradual or abrupt removal of oxygen temporarily inhibits development, it never stops it. It is therefore not surprising that many representatives of the organisms mentioned, in their vegetative and resistant forms, may be found in sewage sludge, when the latter is kept for a short period in the anaerobic phase and is still in the process of digestion. The organisms are not destroyed during the stage of mechanical treatment in the purification plant, they are merely deposited in the sludge, or enriched there. That generally happens when the sedimentation period lasts two hours. If shorter, the vegetative and resistant forms of pathogens may land in the biological stage, together with the mechanically clarified sewage. As established by the Sewage-Research Division of the Bavarian Research Institute for Biology neither vegetative nor resistant forms are injured in the various biological purification plants, irrespective of the system adopted. Hence, from the hygienic point of view, special attention should be paid to faultless sedimentation of all pathogens during the mechanical clarification of sewage.

It may well be asked whether the diseases induced by the aforementioned groups of pathogens still occur to any significant extent in a highly civilized country. Typhoid bacilli can be found in the sewage of all large cities; summer diarrhoea, enteritis and paratyphoid cases occur regularly even in highly civilized countries. Dissemination of parasitic worms in man, especially of Taenia saginata, Ascaris lumbricoides, and Enterobius vermicularis is high even now, as established by the increasing number of Taenia carriers in Central Europe. The susceptibility of man to infection with the bacterial diseases of domestic and wild animals – Salmonellosis – plays now as important a role as before. Domestic and wild animals are heavily infected with worms. Comparative statistical data obtained from slaughterhouses in Central Europe show a relatively high incidence of Ascaris suum in pigs, Ascaris vitulorum in calves, and Fasciola hepatica in sheep and cattle.

In domestic and wild animals infections of the digestive tract with strongylids play an important role (Liebmann, 1953, 1955), especially in connection with cysticercosis in cattle (Forstner, 1961, Liebmann, 1963, 1964/2).

While in the 1930's cysticercosis was recorded in the slaughterhouses of Central Europe, in approximately 0.5% of the cattle, in the period from 1960 to 1966 it rose to 3 – 5%, and in some areas to 10 – 20%.

The relatively high incidence of parasitized domestic animals is explained by inadequate sewage disposal in rural areas, since it is precisely in small communities that the danger of dissemination is very great. These either have no purification plants at all, or are provided with mechanical sedimentation plants only. The purification of sewage in isolated farms constitutes a special problem. Here, a three-chambered cesspool is found, as a rule, the dimensions of which are inadequate for the additionally installed water closets, baths and guest rooms, so that the sedimentation time is too short to ensure annihilation of the pathogens in the sewage and sludge. The farmer prevents overflow of his cesspool either by evacuating it into the fields at short intervals, or by connecting it to the liquid manure tank. As stated earlier, pathogenic organisms are found not only in the liquid and solid excreta of man, but also in those of domestic animals. Examinations carried out by Locher (1954) have established that worm eggs are preserved for long periods in liquid manure. From the standpoint of the parasite, the present treatment of liquid manure provides the best opportunities of dissemination. The various stirring systems introduced in the liquid-manure tank induce embryonation of the worm eggs so that highly infectious material is actually dumped in the pastures. It is therefore impossible to ignore the hygienic problem involved in the treatment of the liquid manure and, at the same time, consider the treatment of sewage as most important. Liquid manure and domestic sewage (or its sludge) play an equally important role in the dissemination of pathogenic agencies. There have been repeated references to the multitude of worm eggs that might be contained in human and animal wastes (Liebmann, 1964/1, 1965). These reports have shown that approximately 1.5 billion worm eggs are carried daily into the sewage works by the sewers of European cities with a population of millions. These worm eggs originate from humans as well as from domestic animals. In the case of drainage areas of large slaughterhouses or fish-canneries, the number of worm eggs is considerably higher (Forstner, 1960).

Once the pathogenic organisms land in the meadows, pastures and fields, they may remain viable there for prolonged periods of time, endangering the health of man and animals. According to Koeser (1966), the Salmonella carried into the open by the inadequately digested sewage sludge may live for weeks in the soil and on grasses. Viable Salmonella can still be detected on grasses 31 days after treatment of the soil with sludge, and in the top soil after 42 days. In suitable soils eggs of Ascaris lumbricoides may remain viable for seven years. In sandy soils, however, the eggs of ascarids are readily killed within a few weeks of dry summer weather. Investigations carried out in Munich have established that for all practical purposes ascarid eggs should be regarded as viable in the soil for about one year. As to their viability on fruits and vegetables, it is known that with the aid of their albuminous coating ascarid eggs strongly adhere to the surface of fruits, vegetables and other objects. Worm eggs, protozoa and their cysts can be carried by flies.

As earlier stated, the pathogenic germs found in domestic sewage sludge may multiply in the period of primary treatment, when sedimentation lasts for two hours. Hence, the hygienic problem of annihilating the pathogens from the sewage in the primary treatment is actually shifted to the sludge treatment. The examinations carried out in Munich have revealed that a digestion temperature of + 10 °C more than 90% of the pathogens are destroyed after three months; at a temperature of 28 - 30° C they are destroyed after two months. Accordingly, the majority of germs are destroyed within two or three months, but not all of them. Viruses, and worm eggs are definitely killed, but not the Salmonella group. On the basis of these findings, directives for the reclamation of sewage in rural areas were formulated in 1951 by the Bavarian Ministry for Internal Affairs in conjunction with the Bavarian Research Institute for Biology (Liebmann, 1953). These directives are still valid.

With the currently adopted system of digestion in heated tanks, the time of digestion never reaches two months. The shortened period of digestion necessarily leads to the presence of numerous pathogens in the digested sludge.

Besides the conventional two-hour mechanical sedimentation, new processing methods have recently been introduced for the purpose of completely eliminating the digestion process. In this connection we may mention the treatment of fresh sewage with calcium and iron salts, the processing known as sludge stabilization, the so-called carboflocculation treatment of sewage, and sewage treatment by composting with or without refuse. During the past 10 years we have examined the content of pathogenic agents in the different processing systems. All these systems fail to comply with the unconditional hygienic requirements according to which all germs pathogenic to man and animals must be retained in the sedimentation stage. With the so-called sludge-stabilizing method enrichment of the worm eggs actually takes place so that subsequent utilization of the sludge only increases the infection danger (Hamm, 1964). Reduction of the digestable organic matter by appropriate aeration systems does not parallel the reduction in the number of worm eggs, because the latter are enclosed in a tight cover, totally impervious to the environment. Therefore, the sludge-stabilizing methods should be further developed in order to eliminate from the reclaimed sludge all organisms pathogenic to man and animal. In connection with the composting of sewage sludge, either alone, or together with refuse, it should be recalled that the resistant forms withstand low temperatures better than high temperatures. Coagulation of albumin, which is attained by heating to +56°C, damages the resistant forms too. Consequently, annihilation of the germs may be expected in sewage-sludge composting provided the processing temperature is maintained for some time above 56°C. Since the pathogenic organism with its resistant form, or the egg, lies in the sludge enclosed in the detrital flakes, the temperature should be raised to 70°C.

Experiences in our country and in others indicate that pasteurization of sewage sludge should proceed at 70°C, for 20 to 25 minutes. We have found that worm eggs are killed within 1 – 2 minutes. However, in order to free the sludge from all other pathogens it is advisable to maintain a temperature of 70 °C for 20 – 25 minutes.

Since installation of pasteurization plants is justified provided there is an adequate number of inhabitants, or a population equivalent, the following measures should be adopted in areas with predominantly rural communities, where the sewage sludge is to be discharged in the fields throughout the year.

1. Separate sewers for human and animal sewage on every farm.
2. Evacuation of the cesspools of human sewage and transportation to central pasteurization plants.

Information obtained so far indicates that this is possible within a radius of about 20 km. The pasteurized sludge may be freely utilized and spread in the fields.

The operation of pasteurization plants should be checked periodically. In our experience membrane-filter tests are quite reliable, while determination of coliform bacilli is adequate for routine tests.

The pasteurized sludge must be specially examined for worm eggs. First, the worm eggs in the sludge should be enriched by appropriate procedures. However, enrichment alone is not enough, since viability of the embryos enclosed in the eggs cannot be established microscopically. Hence, a standard method was advanced by Forstner and Schaetzle (1966) whereby the effective killing properties of the sewage purification can be determined. Beside microscopical examination of the resistant eggs of ascarids and tape worms, this procedure also requires tests of the material in laboratory animals.

In conclusion, from the hygienic standpoint, discharge of the sewage sludge in the fields, in liquid and solid form can be effected the year round provided the sludge has been pasteurized, i.e., heated for 20 – 25 minutes at 70°C.

The following lectures by Mr. Roediger and Mr. Triebel will show that this requirement is not purely theoretical but can be put into practice.

Bibliography

Forstner, M. J. Parasitologische Untersuchungen an der Kläranlage Mindelheim zur Beurteilung des Wurmbefalls von Weiderindern des Abwasserverregnungsgebietes (Parasitological Analysis at the Sewage-Treatment Plant in Mindelheim for Determination of Helminth Infection of Grazing Cattle in the Area Polluted by Waste Water). – Berliner und Münchner Tierärztliche Wochenschrift, 73. 1960.

Forstner, M. J. Wurmeier im Schlachthofabwasser und ihre hygienische Bedeutung (Helminth Eggs in the Waste Waters of Slaughterhouses and their Hygienic Implications). – Münchner Beiträge zur Abwasser-, Fischerei- und Flussbiologie, Vol. 8. 1961.

Forstner, M. J. and M. Schaetzle. Vorschlag für eine Standardmethode zur Beurteilung von Abwasserkläranlagen (Proposed Standard Method for the Evaluation of Sewage-Treatment Plants). – Münchner Beiträge zur Abwasser-, Fischerei- und Flussbiologie, Vol. 13. 1966.

Hamm, A. Wurmeier im Oxydationsgraben, eine biologische Abwasserreinigungsanlage ohne mechanische Vorreinigung (Helminth Eggs in Oxidation Tanks. A Biological Sewage-Purification Plant without Preliminary Mechanical Purification). – Zeitschrift für Parasitenkunde 25. 1964.

Koeser, A. Landwirtschaftliche Nutzung des Faulschlamms und Tierhygiene (Utilization of Digested Sludge in Agriculture and Animal Hygiene). 1966.

Liebmann, H. (Publisher). Die Möglichkeiten der Verbreitung von Zooparasiten des Menschen und der Haustiere durch die landwirtschaftliche Abwasserverwertung (Contingency of Disseminating Zooparasites of Man and Domestic Animals by Reclamation of Sewage in Agriculture). – Münchner Beiträge zur Abwasser-, Fischerei- und Flussbiologie, Vol. 1. 1953.

Liebmann, H. Zooparasiten im Abwasser (Zooparasites in Sewage). – Berliner und Münchner Tierärztliche Wochenschrift 68. 1955.

Liebmann, H. Handbuch der Frischwasser- und Abwasserbiologie (Handbook of the Biology of Fresh and Waste Water), Vol. 2. 1960.

Liebmann, H. Das Verhalten der Bandwurmeier in Kleinkläranlagen mit besonderer Berücksichtigung der Rinderverfinnung (The Behavior of Helminth Eggs in Small Sewage-Treatment Plants, Specially in Regard to Encystment in Cattle). – Münchner Beiträge zur Abwasser-, Fischerei- und Flussbiologie, Vol. 10. 1963.

Liebmann, H. Vergleichende Untersuchungen über den Gehalt des Abwassers an Wurmeiern von Grosstädten Europas, Nordafrikas und Kleinasiens (Comparative Analyses of Helminth-Egg Concentration in Waste Waters of Large Cities in Europe, North-Africa and Asia Minor). – Zeitschrift für Parasitenkunde 25. 1964/1.

Liebmann, H. Parasites in Sewage and the Possibilities of their Extinction. – Second Internat. Conference in Water Pollution Research Tokyo. 1964/2.

Liebmann, H. Die Verwertung und Beseitigung von häuslichen und industriellen Abwasserschlämmen (Reclamation and Removal of Domestic and Industrial Sewage Sludge). – Münchner Beiträge zur Abwasser-, Fischerei- und Flussbiologie Vol. 13. 1966.

Locher, S. Die Widerstandsfähigkeit von Zooparasiteneiern und -larven gegen Gülle und Jauche (Resistance of Eggs and Larvae of Zooparasites to Liquid Manure). – Diss. München. 1954.

THE TECHNIQUE OF SEWAGE-SLUDGE PASTEURIZATION; ACTUAL RESULTS OBTAINED IN EXISTING PLANTS; ECONOMY

By Dr. H. Roediger, Stuttgart

In connection with the statements made by the esteemed preceding speaker, I would like to formulate the requirements from the standpoint of the engineer. Purification plants should first and foremost protect the population and domestic animals from pests, parasites and nuisances; next, they should operate in a profitable and safe way, and thirdly, they should be simply constructed and easily operated. When utilization of sewage sludge in agriculture is envisaged, protection against weed seeds should also be considered. Pathogenic organisms, worm eggs and weed seeds should be removed from the sewage as far as possible, together with the sludge, and then annihilated in the sludge.

The purely aerobic sewage-purification procedures, such as the oxidation tanks, prolonged aeration, or the so-called total purification plants do not comply with these requirements. Aerobic treatment alone leads to considerable enrichment of worms in the sludge, as we have just heard. The so-called stabilized sludge is, actually, only partly oxidized and as such unhygienic; its utilization in agriculture should be strictly avoided, especially if it is still in the process of digestion, when its fetid odor is indeed a nuisance. This hygienic drawback must be added to the other shortcomings of aerobic sewage purification, such as exceptionally high, constant heating costs, without gain of energy, since no sewer gas is produced; high water content and faulty drying of the oxidized sludge.

Incineration of the fresh sludge, although hygienically proof as far as the solids are concerned, is no better since the pathogens found in the filtrate or centrifugate are again discharged in the sewage from which they were removed shortly before. In addition, incineration of fresh sludge has further disadvantages, such as:

difficult dewatering of fresh sludge, owing to the stable water bonds which are not attacked by digestion;
high heating expenses not compensated by gas production;
technical and operational difficulties;
the necessity of employing highly qualified personnel;
the necessity of applying chemicals that reduce, as a rule, the fertilizing value of the sludge;
the yield of large quantities of ash that cannot be utilized;
no buffering for equilibration and neutralization of injurious compounds, but continuous operation with all inherent disadvantages.

Hence, the classical system of sedimentation and digestion of the sludge cannot be bypassed. So far, all experiments which aimed at avoiding it have failed because this system has decisive economic, technical, operational and hygienic advantages.

The mechanically sedimented sludge and the biological sludge are removed from the sewage in the cheapest way, together with about 90% of the pathogenic organisms, worm eggs and weed seeds, whereupon the sludge mixture is transferred into digestion tanks and subjected to anaerobic alkaline digestion. The digestion process, as already indirectly mentioned, is distinguished by several advantages, such as buffering, breakdown of water-bonds, reduction of the sludge quantity to $^1/_4$ or $^1/_3$ of the original volume (thereby reducing also the required sludge-processing installations); yielding of sewer gas (hence providing a source of energy instead of requiring large quantities of fuel) and, finally, elimination of further digestion of the sludge. Moreover, the sludge is concomitantly disinfected — to a certain degree — since part of the pathogens, worm eggs, and weed seeds are killed in the course of alkaline digestion, while another part is markedly impaired; some, however, withstand the process of digestion and within a relatively short period are able to resume their life activities. Among the latter we should mention in the first place the infection agencies of tuberculosis and anthrax, some worm eggs and certain plant seeds, for example, tomato seeds.

This incompletely disinfected digested sludge can be naturally or artificially dewatered and dried, and then either composted (usually together with household refuse), or directly disposed in the fields; it may also be dried at high temperatures, or incinerated. However, it can be left as it is, pasteurized and simply disposed in the fields and pastures throughout the year.

Hygienically, the most satisfactory procedure is **pasteurization** and **disposal of wet** digested sludge, because the material is not artificially dewatered (thus avoiding return of the pathogens into the sewage), each sludge particle is uniformly heated (not as in composting in the course of which the heat evolves mainly inside the compost heap, and even if the latter is repeatedly turned there is no certainty that each particle has been heated to 65° or 70°C.) Besides, pasteurization and disposal of the wet sludge do not require anyone to come in contact with the material (and we must give due consideration to the personnel), since the entire process takes place in closed conduits and containers. Therefore, not only the sludge planned for wet disposal should be pasteurized, but any digested sludge that leaves the plant, irrespective of further processing and utilization.

Pasteurization is particularly advantageous because the sludge is thereby purified, while its content of nutrient matter for plants remains intact.

As we shall see in the last part of this lecture, pasteurization requires only a fraction of the sewer gas evolved during the digestion process. Disposal of liquid sludge is, by far, the cheapest of all sewage sludge-reclamation procedures, as we shall probably hear in detail from our building director, Mr. Triebel. In addition, the liquid-sludge disposal has the advantages of requiring no allocation of special space at the purification plant and of the sludge of each day's operation being indeed disposed of, without remnants being left behind, as for example the ashes after incineration.

It follows from the above-said that **digestion, pasteurization** and **liquid-sludge disposal** doubtlessly provide the most economic and the most satisfactory procedure from the operational and hygienic points of view. It is therefore increasingly adopted whenever a practical solution of sewage disposal is sought. In Switzerland, too, installation of pasteurization equipment is now in progress in many of the old and new purification plants. Since perfectly hygienic sludge is a most urgent requirement in areas with highly developed meadows and pastures, there appears to be a trend now to make provision in every purification plant for sludge digestion and pasteurization, in future. This approach will certainly create a precedent and serve as a model for other countries, so that the installation of pasteurization equipment in purification plants will be a matter of course.

Pasteurization infers heating to a certain temperature, which if maintained for an adequate time will kill all undesirable organisms in the sludge. While a temperature of about 70°C is generally considered adequate for pasteurization of digested sludge, the duration of heating is established in accordance with the specific requirements; for example, if annihilation of worm eggs alone is intended, — as in Darmstadt — pasteurization of 4 minutes proves effective. If elimination of all injurious organisms is envisaged — as in Lüneburg — 25 to 30 minutes are required. The correlation between temperature and duration of exposure for the elimination of some of the main disease agencies is evident from the following examples.

Exposure (in minutes) for destruction of	At temperatures of					
	50	55	60	65	70°C	
Cysts of Entamoeba histolytica	5					min
Eggs of Ascaris lumbricoides	60	7				min
Brucella abortus		60		3		min
Corynebacterium diphteria		45			4	min
Salmonella typhosa			30		4	min
Escherichia coli			60		5	min
Micrococcus pygogenes var. aureus					20	min
Mycobacterium tuberculosis var promixis					20	min
Viruses					25	min

Consequently, in order to achieve complete purification of sewage sludge heating to 70°C for 25 to 30 minutes was adopted in some digestion-pasteurization plants a decade ago.

The great rise in temperature from 30°C (digesting temperature) to 70 °C (pasteurization temperature) is attained by the direct inflow of finely dispersed steam under low pressure (below 0.5 atm) in the sludge-digesting conduit, homogeneously distributed with the aid of a special nozzle. As soon as the steam flows in, it condenses in the finest and most homogeneous distribution, so that the heat required for vaporization (539 kcal/1 water) is istantaneously released, and all sludge particles are uniformly heated throughout the sludge conduit. This uniform heating of even the minutest sludge particle is ideally assisted by the formation of steam whirls inside the special nozzle. A better, more uniform and simpler means of sludge pasteurization than by way of this special nozzle would be difficult to find. This special nozzle, which actually consists of a great number of single injectors, has the additional property of keeping itself free from blockage or incrustation. All nozzles mounted for this purpose years ago have proved excellent in their performance and reliability.

All other kinds of heat-exchangers for heating the sludge to 70°C have proved to be technically and hygienically unsatisfactory. The temperature gradient between the heating medium and the medium to be heated is too small to ensure effective and uniform heat distribution. Moreover, there is the constant danger of incrustation and the inevitable operational shortcomings as a consequence thereof. Further, the heat evolved by the heat exchanger is limited by the area of the exchanger. The technically and hygienically perfect procedure is the uniform inlet of steam into the sludge stream, as applied in the food industry. Both high-pressure and low-pressure steam may be used. But, since high-pressure steam infers the compliance with stringent structural and operational regulations it is always preferable to use low-pressure steam, which is not subject to any limiting regulations. In order to distribute the low-pressure steam as homogeneously as possible in the heavy medium – sludge – the aforementioned nozzles, which have been specially designed for this purpose, are required.

The heat output of the special nozzle is not limited by any heat-exchange area. This kind of injector rather enables the inflow of heat to such an extent that the rise in temperature in any amount of sludge is in fact dependent only upon the size of the heat producer.

Nevertheless, a heating cycle will naturally be adopted, whereby the sludge is not heated directly from 30° to 70°C, i.e., its temperature raised by 40°C at once, but gradually heated by passing repeatedly through the steam nozzle, i.e. within a certain time interval, which depends upon the size of the boiler selected. In this way considerably smaller boilers may suffice, thus avoiding the giant boilers such as those available only in large purification plants. The heat required will be supplied either by a special heater, or by the boiler installed for heating the digestion unit and for which the sewer gas itself is used. The same heating unit will then be used, for example, in daytime for heating the digestion tank, and at night for sludge pasteurization. On the basis of the absolutely safe operation of this heating system, another step forward may be taken, as has been done in Marburg, by using the same low-pressure steam nozzle in both processes, digestion and pasteurization. This system is also being adopted in very large plants, such as the purification plant of the Bulgarian capital, Sofia.

In order to maintain the pasteurization temperature for the respective duration (from about4 to approximately 30 minutes) imposed by the local hygienic requirements, a secondary reaction tank is provided. Secondary digestion tanks can be easily used for this purpose, as is being done in Buxtehude.

In order to ensure continuous pasteurization, two secondary tanks are installed. The entire pasteurization process, including temperature and time control, can be arranged to proceed fully automatically, which is, of course, important for night operation.

The heat introduced in the form of low-pressure steam is released as condense heat and as a condensate of 100°C, and is fully and entirely utilized for sludge heating. No heat can be recovered or need be recovered here. A relatively small amount of the heat supplied might be recovered by the heat-exchange of very large areas, i.e., by transferring the digested sludge at 30° or 35°C to the emptied pasteurization containers. This, however, proved technically and economically unsuitable, so that the investment, maintenance and operation costs are not justified, particularly since the energy source is produced by the process itself in the form of sewer gas. Moreover, operation becomes too intricate because one of the four indispensable reaction tanks must be emptied at precisely the same time as another tank is filled. Hence, no heat-recovery is aimed at in the described pasteurization system.

To be independent of the transport of pasteurized sludge, it was found expedient to have a silo or reservoir attached to the pasteurization plant.

According to prevailing conditions, shallow reservoirs (for example, scooped out in the soil) may serve also for cooling the sludge if the latter is not channeled in water-cooled pipes from the pasteurization tank to the reservoir. The pasteurized sludge is then taken from the reservoir by tankers, sludge-suction tankers, or simple refuse carts directly into the meadows, fields and pastures, or to areas to be meliorated or, otherwise, to fill old stone quarries, pits, etc.

The system described can also be used for the pasteurization of sludge from oxidation ditches, or of fresh undigested sludge, as planned for Nette Nierverband). In these cases, which arise in specific conditions, the heat required for pasteurization must be obtained from other fuels, since no sewer gas is generated in the works; the pasteurization plant cannot be connected with the heating system of the digestion tank, but must have its own installation. Pasteurization plants built to supplement existing sewage-sludge digesting works generally are independent units, as, for instance, the one in Winterthur.

However, if pasteurization is envisaged from the start, it is certainly more expedient to combine it, as described, with the heating system of the digestion tanks. Moreover, if the reaction tanks are built in the open, there is actually no need for additional space inside the plant. The initial costs are thus also considerably reduced. The operation costs consist mainly of heating costs, and with the sludge-digestion in process, heating is obtained in any case with only a fraction of the sewer gas evolved.

Even if the sewer gas is used for the production of energy required for the inflow of oxygen in the biological sewage purification, there is sufficient gas left for digestion and pasteurization, as evident from the following calculation. These energy-balances are based upon Imhoff's values, which are very cautiously assessed. The corresponding pages in "Taschenbuch der Stadtentwässerung", 21st edition, are indicated. The equivalent of 10,000 inhabitants is the unit chosen for calculation, so that the corresponding values for the respective plant sizes can easily be obtained by simple multiplication.

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BOD - inflow: 10,000 · 35 g/1/day		= 350 kg BOD/day
BOD-degradation at 90% purification:		= 315 kg BOD/day

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Air requirement per kg BOD-degradation by inflow of finely dispersed compressed air to a depth of 3.0 m		32.5 m^3/kg BOD
Total requirement of compressed air		10,240 m^3/day
Power requirement of the engine shaft for sewer gas at a pressure of 1.0 m in the conduits, and 76% compressor efficiency	$\frac{10{,}240{,}000 \cdot 4.0}{75 \cdot 3{,}600 \cdot 0.76}$	200 HP maximum/day
Sewer gas required for that	200 · 0.4	80 m^3/day
thereby inflowing waste heat	200 · 900	180,000 cal/day

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At fully loaded activated-sludge plant		
fresh sludge		= 17.50 m^3/day
digested sludge	30% of 17.50	5.25 m^3/day
Total solids		= 790 kg/day
Organic solids	minimum	= 500 kg/day

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Sewer gas production per kg organic solids at 30°C	$\frac{540 \cdot 750 + (790-540) \cdot 750/2}{790}$	= 630 1/kg
Sewer gas inflow	500 · 0.630	= 315 m^3/day
Sewer gas consumption for generation of power	−)	80 m^3/day
Residual sewer gas		235 m^3/day

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Heating value of sewer gas		5,500 cal/m^3
Heat production at 80% of boiler's effective potential	235 · 5,500 · 0.80	1,034,000 cal/day
Waste heat of the sewer-gas engine	+)	180,000 cal/day
Available amount of heat		1,214,000 cal/day
Heat required in winter for warming the fresh sludge	17,500 · 25°C	437,500 cal/day
Heat required in winter for heating the digestion tank and buildings	approx.	500,000 cal/day
Heat required for pasteurization of digested sludge	5,250 · 50°C	262,500 cal/day
Heat requirement in winter		1,200,000 cal/day
Heat excess in winter:		14,000 cal/day

Hence, if properly managed the sewer-gas production will meet the power demand of biological sewage purification, as well as the heat demand of the entire purification plant, including the heat required for pasteurization, even in winter.

Naturally, a considerably greater excess of heat is generated in the warmer seasons. Less heat, and correspondingly more power can be produced then, with at least one unit producing additional electric power for pumps, etc. Since the amount of electric power produced cannot meet all requirements it may be used for replacing the more expensive day-power.

Thus, it has been proved that in normal conditions and with appropriate methods of intensive and rational utilization, the sewer gas can meet the entire heat demand of the digestion and pasteurization processes, the total power demand for the sewer-aeration in biological purification and, according to prevailing conditions, at least a major part of the electrical power demand of the purification plant. Moreover, there are purification plants that generate all the electric power they need, as for example those of Munich, Düsseldorf, and Bremen. The Bremen plant is not even connected with the main electricity supply, and even the engines are driven with sewer gas by direct coupling to the blowers. In this way the efficiency-losses of generator and electrical motor are avoided. Even small purification plants with a population equivalent of 10,000 to 20,000 may attain a large degree of independence. By means of skilfully geared sludge-digestion and sewage aeration purification plants can become largely autonomous, i.e., they may produce almost the entire amount of power and heat required for all the processes involved.

It is our duty to the national economy and public health to build and equip the purification plants in accordance with the most up-to-date technical knowledge, to carry out intensive digestion processes and biological sewage purification, to obtain maximum production and utilization of sewer gas and, at the same time, comply with the hygienic requirements.

EXPERIENCES WITH SLUDGE PASTEURIZATION AT THE NIERSVERBAND; TECHNIQUE AND ECONOMY

By Building Director W. Triebel, Niersverband Viersen

A critical review of the experiences of the Niersverband in connection with sludge pasteurization (technique and economy) requires at least a short description of the sludge treatment in the specific local conditions. A few introductory remarks are necessary, however, for a clear understanding of the following.

At the Niersverband the sewage sludge is reclaimed in two ways: first, it is converted into a dry product, "Humusit," by artificial dewatering in vacuum filters in conjunction with heat-drying in rotating drums, or else in a suspended drier; secondly, the wet sludge is disposed on fields, meadows and pastures. The second method is relevant here, since it is the only decisive one from the quantitative aspect.

Disposal of the wet sludge is the cheapest procedure not only in the opinion of the Niersverband but also in the opinion of others. Mr. Kershaw of the West Hertfordshire Main Drainage Authority and Director of the Maple Lodge Sewage Disposal Works has repeatedly expressed the same opinion. The procedure is not only the most economical, but also the most reasonable, and the most effective for the farmer. Economically, natural dewatering of sewage-sludge in drying beds might prove competitive under favorable conditions, but, as a rule, the customary drying procedure is more expensive and less satisfactory. In large works the cost involved in the drying-bed procedure is about twice as high as that of wet disposal. As compared with the dried sludge the disposal of wet sludge has the following advantages.

Soil and vegetation receive the entire nutritive value of the sludge, i.e., including the nutrients dissolved in the water; the sludge is not contaminated with weed seeds; even distribution of the sludge in doses of appropriate concentration is ensured, and the nutrients are not only deposited on the soil surface but carried with the water into the soil. And, above all, the demands made on the farmer's time and labor are minimal.

Nevertheless, the wet disposal has also its shortcomings. It is generally claimed that disposal of wet sludge is a "fine-weather procedure" since difficulties are encountered with the wet-sludge disposal in fields during prolonged spells of rainy weather. This theory contributes to impeding the wide adoption of wet disposal, but is not valid. In fact, the continuous practice of wet disposal by the Niersverband, in summer and winter during the past six years, clearly proves the opposite. Two drawbacks that may be connected with this type of disposal – but need not occur – should be taken into account from the beginning: the danger of infection to man and animals, and the accumulation of damaging material, i.e., of metallic salts in the soil and in the plants. It is beyond our scope to enlarge on the hygienic aspect which is generally known and has been expounded by experts. However, it should be mentioned that the second problem was also thoroughly examined by the Niersverband, in cooperation with well-known authorities in this field. Although we should not anticipate the report by Prof. Dr. Kick, Director of the Institute of Agricultural Chemistry of the Bonn University, and co-workers, it is already certain (not just assumed) from the results obtained that given proper management this second suspicion is unfounded. In this connection it should be emphasized here also that, whether dry or wet, the sludge intended for use in agriculture must not contain excessive amounts of material injurious to plants or animals. In practice this prerequisite infers the necessity of continuous testing of the sludge, examining its composition and behavior, so that in the case of any suspicions arising in regard to its bacterial or chemical properties disposal can immediately be discontinued until the position is remedied. The rural areas are no dumping sites for all kinds of refuse; they are productive areas, which should be treated as such.

As to pasteurization, in the light of the aforesaid, pasteurization is a hygienic safeguard that, doubtessly, increases the disposal expenses of the wet sludge. A balance sheet of the sewage-processing costs of a large plant, the Group-Sewage-Plant I of the Niersverband was published in the GWF, No. 18, 1967; we shall refer to it later. The problem is also mentioned in the 1966 report of the Niersverband. Some of the following figures are based on these publications. However, it should be made clear from the beginning that pasteurization represents only one procedure of sewage processing, and that in small sewage works pasteurization may have to be discarded as a means of obtaining hygienically satisfactory sludge, for economic reasons. It is difficult to establish with certainty the size of sewage works that may no longer be considered suitable for pasteurization from an economic point of view since many different factors are involved. At present, the Niersverband can only report on the actual running expenses of one single sewage-treatment plant. Further data on pasteurization, though based on detailed calculations, do not represent actual operational costs.

Before entering into details of running costs, the technical structure of the pasteurization plant of the Group-Sewage Plant I of the Niersverband should be briefly described. The pasteurization system was chosen so as to ensure that every single grain of sludge would be heated for the prescribed time. This implies elimination of any kind of short-circuits in the electric current, and automatic regulation of temperature. For good reason special attention was paid to incrustation. Incrustations are a greater potential danger in pasteurization than in digestion heating chambers, owing to the higher temperatures involved. In addition, incrustations are correlated with the composition of the sludge, e.g., the content of calcium, iron, and other chemical components, and, in the first place, with the compounds precipitated by heating. As an example, an excellent heat-exchanger of spiral structure should be mentioned. The operational efficiency and suitability of this structure were established in the Schwabing hospital, Munich, in the Büssum sewage works in Holland, and in many other places, where this heat exchanger has been functioning successfully.

This implement was then also tried in the Niersverband sewage works, but proved a complete failure. The fine-grained sludge of the Group-Sewage Plant I settled so rapidly in the narrow channels of the heat exchanger that this implement had to be rejected as useless. We then arrived at the conclusion that in order to prevent incrustation any direct transfer of heat from metallic surfaces to the sludge should be avoided, and decided on direct heating of the sludge itself. A similar conclusion was clearly expressed in Dr. Roediger's lecture. A further consideration was decisive for our plant: limitation of heat consumption, which meant provision of a heat exchanger. This is an economic problem since recuperation of the heat may radically affect the running expenses of the plant. These two purposes, prevention of incrustation and recuperation of heat led to the construction illustrated in Figure 1.

From the storage tank on the left the concentrated digested sludge is pumped into a preheating chamber. The sludge entering the chamber has a temperature of 18°C and is preheated to 38°C by the vapors from the blow-off tank, with which it is connected. The preheater is under vacuum, 0.1 atm, established with the aid of a vacuum pump. While passing through several drip pans the sludge is enveloped by the steam and heated.

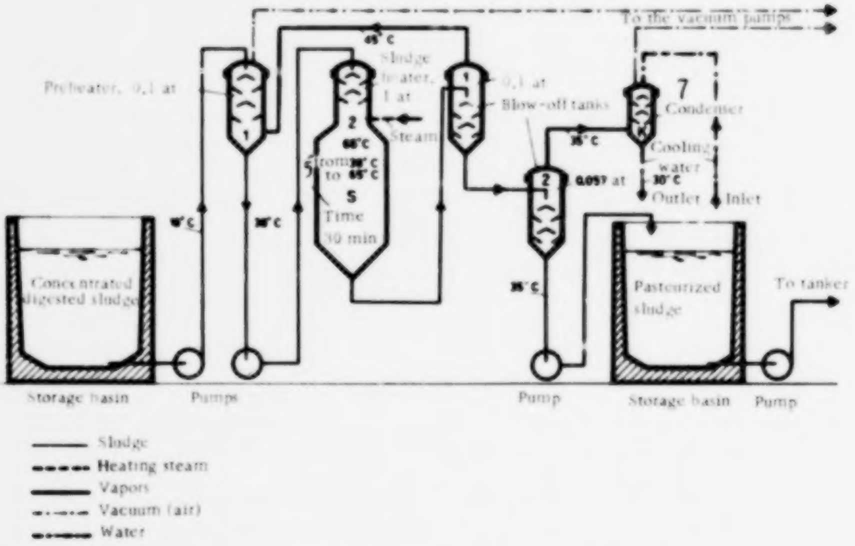
To the vacuum pumps
Preheater, 0,1 at
1
Sludge heater, 1 at
2
Steam
5
from
to
5
Time 30 min
0,1 at
Blow-off tanks
1
2
0,059 at
7
Condenser
Cooling water
Outlet
Inlet
Concentrated digested sludge
Pasteurized sludge
To tanker
Storage basin
Pumps
Pump
Storage basin
Pump
Sludge
Heating steam
Vapors
Vacuum (air)
Water

FIGURE 1. Diagram of sludge pasteurization in the Group-Sewage Plant I of the Niersverband Viersen

With a second pump and under pressure of 1at the sludge is then passed into the sludge heater, where it is heated by steam to 65° – 70°, according to the temperature indicated by the thermoregulator. Heating proceeds here also by contact of the sludge with the steam, while the sludge is dripping over drip pans. We are satisfied with heating the sludge to 70° – 65°, whereupon it is passed into a retention tank for 30 minutes. From here, the sludge reaches the blow-off tank No. 1, where it is cooled to 45°, under vacuum, at 0.1 atm, and thence to blow-off tank No. 2, where it is further cooled to 35°, under vacuum, at 0.057 at. The sludge is then transferred to the storage tank from which the tankers are filled. The vapors from blow-off tank No. 2 are channeled into a condenser, whereupon addition of cooling water, they are condensed and drained off.

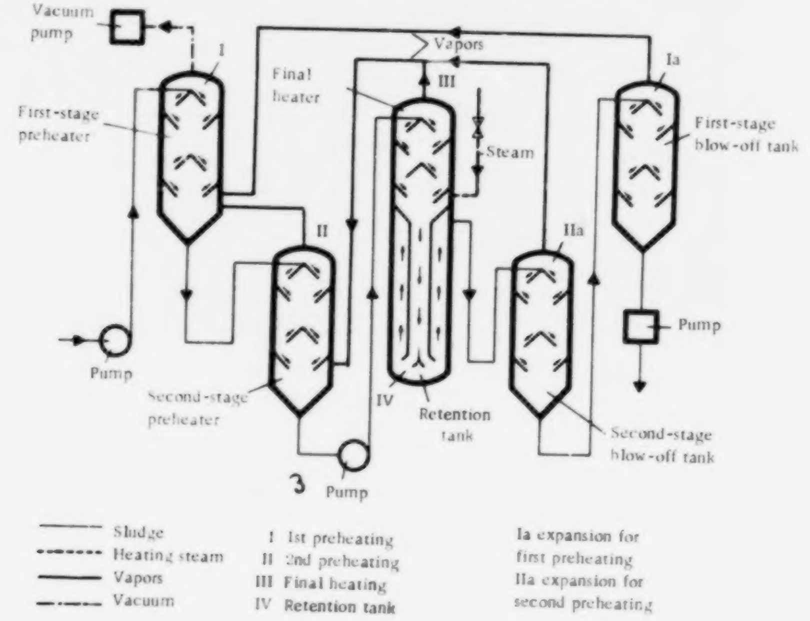
Vacuum pump
I
Vapors
Ia
Final heater
III
First-stage preheater
Steam
First-stage blow-off tank
II
IIa
Pump
Pump
Second-stage preheater
IV
Retention tank
Second-stage blow-off tank
3
Pump
Sludge
Heating steam
Vapors
Vacuum
I 1st preheating
II 2nd preheating
III Final heating
IV Retention tank
Ia expansion for first preheating
IIa expansion for second preheating

FIGURE 2. Pasteurization with two-stage preheating.

We designate this procedure as one-stage heat recuperation. This one-stage heat recuperation is considered economically sound if the daily quantities of sludge amount to a minimum of 200 – 250 m^3; with a daily sludge inflow of 400 – 500 m^3, the two-stage heat-recuperation plant is indicated, and in works processing daily 1,000 m^3 of sludge and over a three-stage heat recuperation system is considered the most economical, whereby one condenser may be eliminated. Since the described pasteurization plant has no metallic heat exchanger all the effects of incrustation, soilage and blockage are eliminated. Cleaning of tanks and pipes is carried out at the end of the season, i.e., twice a year, so that operation is thereby not discontinued or unduly hampered.

Figure 3 shows the assembly of a single tank of the pasteurization plant, with the sludge heater and tarrying tank in the foreground. In Figure 4 the structural connection of the pasteurization plant with the second-concentration tank can be seen. Both installations have a common engine room for pumps, switchboards, etc.

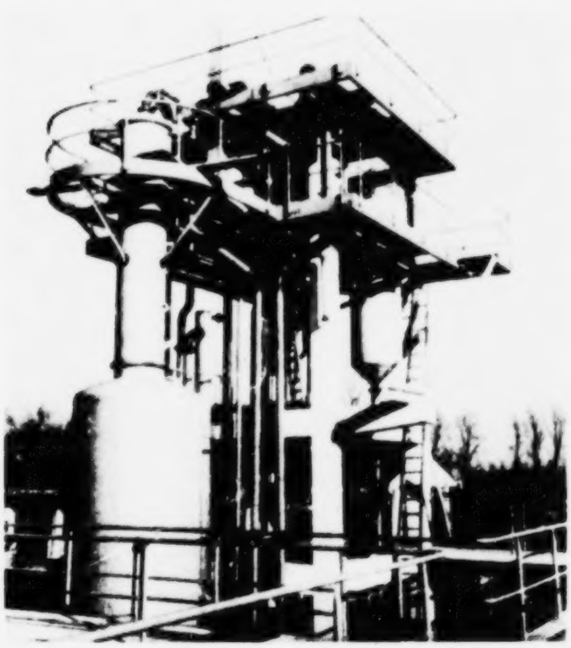

FIGURE 3. Assembly of pasteurization plant

The pasteurization plant is operated only in the growth season, i.e., it is discontinued in winter because no cattle then stay in the pastures and the sludge is disposed mainly in the fields.

The sludge disposal in fields and pastures in relation to the time of the year is illustrated in Figure 5.

The State Veterinary Research Bureau NRW in Münster has thoroughly investigated this aspect and a report was published by Dr. Köser (director of the Bureau at that time) in "Wasser und Nahrung", No. 4. From a report to the Ministry we reproduce Table 1, which presents in brief the results of separate analyses of grass samples, soil samples and sludge crusts.

A total of 176 samples were withdrawn from pasture areas that had been subjected to sludge treatment shortly before, or long before sampling; 72 grass samples, 73 soil samples, and 31 sludge-crust samples were collected. Sampling proceeded from the end of March until the end of November, 1964, under strictly sterile conditions; the individual samples were packed in sterile paper bags or bottles; the instruments were sterilized by heat prior to each sampling. No animal tests were carried out at this stage because previous analyses over a number of years have shown that there are hardly any viable tubercle bacilli in the sludge disposed on pasture land.

As earlier mentioned, no definite figures can be given as to the cost of pasteurization. We therefore present the comparative expenses of two sewage works which differ greatly in size and operation, taking into account not only the cost of pasteurization, but the latter in correlation with the other expenses of sewage treatment. Calculation of pasteurization costs alone could lead to erroneous results. Pasteurization costs should always be correlated with the general costs of sewage treatment.

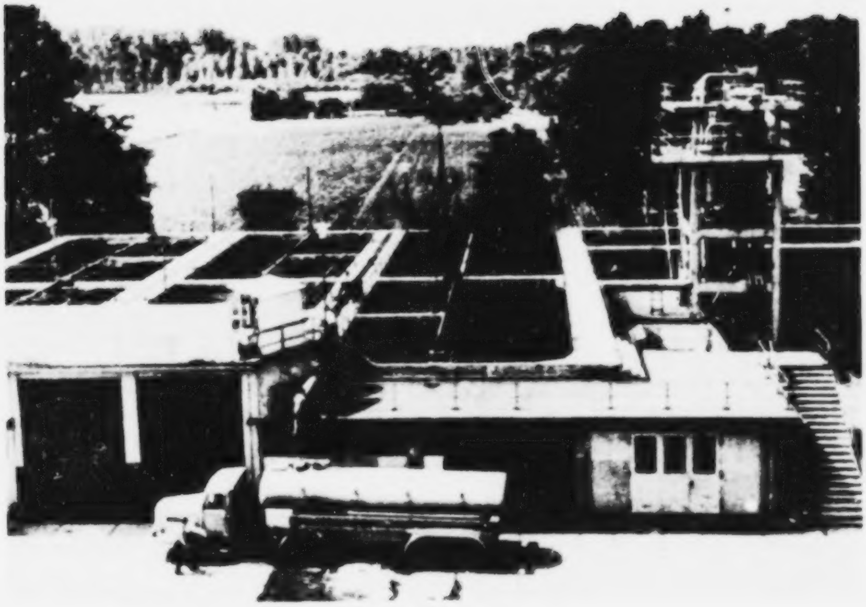

FIGURE 4. Pasteurization plant with secondary concentration tank

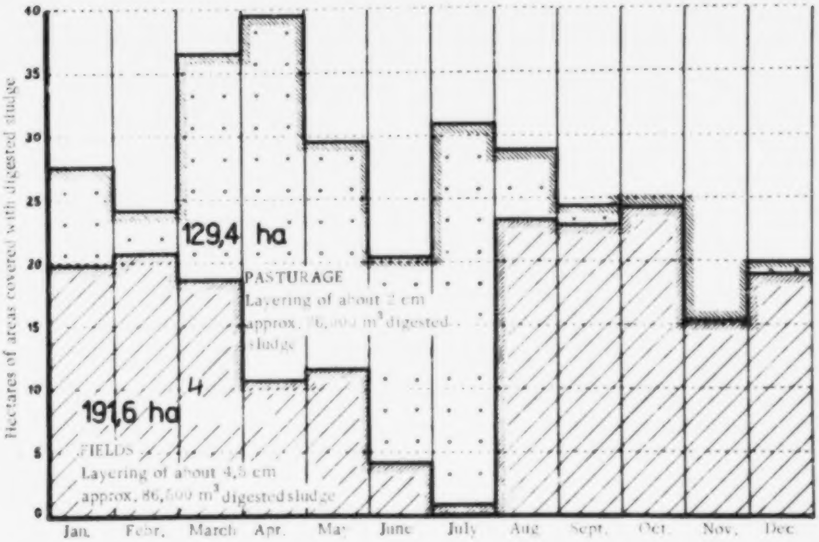

FIGURE 5. Sludge disposal in fields and pastures

TABLE I. Analyses of pasturage

Sludge treatment lasted	Plants		Topsoil		Sludge crust	
	Total number	**Salmonella**	Total number	**Salmonella**	Total number	**Salmonella**
Untreated	2	0	2	0	-	-
4 – 6 days	4	2	4	3	3	3
1 – 2 weeks	5	0	5	2	3	2
2 – 3 weeks	8	0	8	4	3	3
3 – 4 weeks	6	0	6	2	2	2
4 – 5 weeks	2	0	2	2	-	-
5 – 6 weeks	3	0	3	0	2	2
6 – 7 weeks	2	0	2	1	1	-
7 – 8 weeks	10	0	10	3	5	5
8 – 9 weeks	5	0	5	3	2	2
9 – 10 weeks	7	0	8	1	1	1
10 – 11 weeks	4	0	4	0	1	1
11 – 12 weeks	5	0	5	0	3	2
12 – 13 weeks	1	0	1	0	1	1
13 – 14 weeks	2	0	2	0	1	1
14 – 15 weeks	3	0	3	0	-	-
15 – 16 weeks	3	0	3	0	3	1
Total	72	2	73	21	31	26

The sludge examined after about 100 days refers to a formerly superficial layer that once harbored Salmonella, but was sampled in a deep buried layer of compacted sludge

Table 2 shows in the left-hand column the values for the Group-Sewage Plant I, in Mönchengladbach-Neuwerk, and in the right-hand column the corresponding values for the Group-Sewage Works of Nette, both from the Niersverband region.

Both these sewage works have adopted mechanical clarification and two-stage biological treatment in the activated-sludge procedure, with the intercalation of a chemical precipitation. At the Group-Sewage Plant I the sewage of textile and paper industries predominates. About $^2/_5$ of the sewage is domestic and $^3/_5$ industrial. In Nette, the textile-industry wastes are supplemented by those of the metal industry, especially the galvanic industry. The working load of Sewage Plant I is 8 times as high as that of Nette. But the relevant difference in the present comparison is that in Sewage-Plant I the sewage is digested in heated chambers in one stage, whereas in Nette, digestion is eliminated and only fresh sewage is processed. By using the costs listed in Table 2 for concentration, digestion and pasteurization, the total expenditure for wet disposal was calculated as listed in Table 3.

The cost analysis reveals that the pasteurization costs in Sewage Plant I amount to about 0.29 DM, or $^1/_{12}$ of the total expenditure of 3.65 DM for the disposal of wet sludge; hence the expenditure for wet disposal is increased by pasteurization by approximately 8.5% only. By contrast, the pasteurization costs in Nette amount to 1.32 DM, or more than $^1/_3$ of the total expenditure of 2.82 DM for the disposal of wet sludge; in this case pasteurization raises the costs of wet disposal by approximately 50%. Two factors are mainly responsible for this difference: the considerably smaller works in Nette necessarily entail a larger share in capital costs, 1.34 DM as against 0.34 DM; and the expenditure on combustion oil, 0.73 DM/m^3. If the costs of the sewer gas used for pasteurization and digestion in the Group-Sewage Plant I were not given as 0, as in Table 2, (and this is theoretically quite plausible), then the Nette sewage plant would appear to be at an advantage.

TABLE 2. Sewage-processing costs

Group-Sewage Plant I	Group-Sewage Plant Nette
1. Fresh sludge (mech.-biol.) concentrated to 92,59% moisture 270,000 m^3/year	Fresh sludge (mech.-biol.) concentrated to 96% moisture 35,000 m^3/year
2. Digested sludge 94,1% moisture 270,000 m^3/year	–
3. Concentration and washing 92,91% moisture 172,000 m^3/year	Concentration 93% moisture 20,000 m^3/year
4. Wet disposal 130,000 m^3/year Filtration and drying 42,000 m^3/year	Wet disposal 20,000 m^3/year
5. Digestion costs after deduction of income from gas surplus (heating-gas value fixed at 0) 0,78 DM/m^3 concentrated sludge	–
6. Concentration and washing costs 0,49 DM/m^3 conc sludge	Concentration costs 0,40 DM/m^3 conc. sludge
7. Pasteurization cost (heating cost = 0) 0,57 DM/m^3 conc sludge	Pasteurization cost, 2,64 DM/m^3 conc. sludge
8. The cost of 0,57 DM/m^3 consists of capital cost 0,34 DM/m^3 (65,000 m^3/year) Running and maintenance 0,23 DM/m^3 0,57 DM/m^3 When 130,000 m^3 are pasteurized the cost drops to 0,57 − 0,17 = 0,40 DM/m^3	The cost 2,64 DM/m^3 consists of Capital cost 1,34 DM/m^3 (10,000 m^3/year) Combustion oil 0,73 DM/m^3 Water and current 0,12 DM/m^3 Service and maintenance 0,45 DM/m^3 2,64 DM/m^3 When 20,000 m^3 are pasteurized the cost drops to 2,64 − 0,67 = 1,97 DM/m^3
9. Disposal, 2,10 DM/m^3	Disposal, 2,10 DM/m^3

TABLE 3. Total cost of wet disposal

Group-Sewage Plant I	Group-Sewage Plant Nette
Processing costs of 130,000 m^3 sludge **without** disposal when 130,000 m^3 sludge are pasteurized: 0,78 + 0,49 + 0,40 = 1,67 DM/m^3 conc. sludge; when 65,000 m^3 sludge are pasteurized: $0,78 + 0,49 + \frac{0,57}{2} = 1,55$ DM/m^3 conc. sludge	Processing costs of 20,000 m^3 sludge **without** disposal when 20,000 m^3 sludge are pasteurized: 0,40 + 1,97 = 2,37 DM/m^3 conc. sludge; when 10,000 m^3 sludge are pasteurized: $0,40 + \frac{2,64}{2} = 1,72$ DM/m^3 conc. sludge
Total costs of sludge processing **and** disposal when 130,000 m^3 sludge are pasteurized: 1,67 + 2,10 = 3,77 DM/m^3; when 65,000 m^3 sludge are pasteurized: 1,55 + 2,10 = 3,65 DM/m^3	Total costs of processing **and** disposal when 20,000 m^3 sludge are pasteurized: 2,37 + 2,10 = 4,47 DM/m^3; when 10,000 m^3 sludge are pasteurized: 1,72 + 2,10 = 3,82 DM/m^3
Total expenditure for pasteurization of 130,000 m^3 sludge: 130,000 · 3,77 = 490,100 DM; for pasteurization of 65,000 m^3 sludge: 130,000 · 3,65 = 474,500 DM*	Total expenditure for pasteurization of 20,000 m^3 sludge: 20,000 · 4,47 = 89,400 DM; for pasteurization of 10,000 m^3 sludge: 20,000 · 3,82 = 76,400 DM

* [The German text reads 438,000 which,evidently, is a misprint.]

The more so, since the costs listed for Sewage-Plant I are based on the actual operation accounts, whereas those of the Nette Works have, for reasons of caution, been calculated on the basis of increased prices.

The great difference in the cost of pasteurization alone (0.57 DM in Sewage-Plant I, as against 2.64 DM in Nette) represents essentially the price that has to be paid for the exclusion of digestion. The cost comparison as presented fails to indicate clearly whether the elimination of digesting tanks is economically advisable in the disposal of wet sludge. For medium-sized plants, such as the Nette Works, this question may have to be answered in the affirmative, although at present it cannot yet be proved. The Niersverband intends to establish an additional plant of about the same size, without digestion tanks. As soon as this plant is ready, clear results will be available. Until then pasteurization should be considered a necessary component of wet disposal and should be further developed.

No significant advantages are likely to be revealed as resulting from the digestion of sludge when wet disposal is planned, and digestion is not strictly necessary in order to reduce the amount of sludge. Reduction depends much more upon concentration. Simplification of operation of the sewage-works by eliminating digestion is even more justified since digestion does not eliminate the necessity for pasteurization. Whether the additional reduction of sludge as achieved by digestion is equivalent to the reduction obtained by concentration of fresh sludge in conjunction with the savings of combustion oil necessitated by digestion, should be established in practice, in order to justify the extra capital cost and running expenses of digestion. However, in the wet-disposal procedure reduction of the sludge amount is economically decisive. In this connection, some accurately calculated expenses of the Nette Works should be mentioned.

As evident from Table 3, the wet disposal of half the amount of pasteurized sludge costs 3.82 DM/m^3 conc. sludge. If the sludge were not disposed wet but after dewatering by filtration, it would cost 7.93 DM/m^3 concentrated fresh sludge, and a relatively large amount of filter cakes would accumulate waiting to be removed

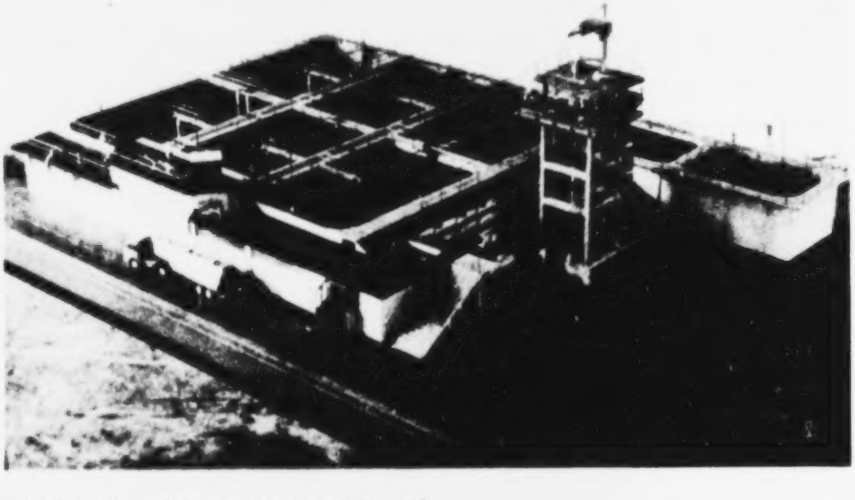

FIGURE 6. Model of the secondary concentration tank

by the farmers. From our experience it is rather difficult to get the farmers to effect this removal. If the plant undertakes the disposal, the cost increases to 10.70 DM/m^3.

It follows from the above-said that dewatering by filtration is not economical, and the Niersverband therefore suspended filtration long ago in both the Dülken and Nette works.

If the sewage sludge were digested in the Nette Works its wet disposal would cost 3.70 DM and if half the amount of the digested sludge were pasteurized, it would cost 4.41 DM. Thus wet disposal of pasteurized fresh sludge costs 3.82 DM, whereas the cost of wet disposal of pasteurized digested sludge rises to 4.41 DM. All figures refer to 1 m^3 of concentrated fresh sludge. On the basis of these figures alone it is worth considering whether digestion is really necessary if wet disposal is planned.

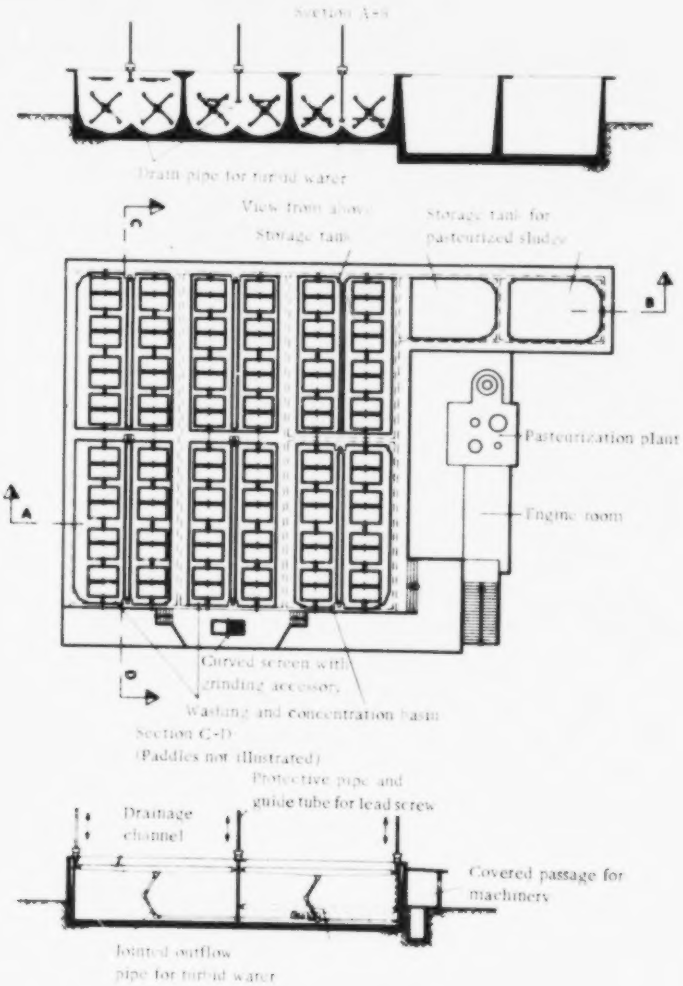
Section A-B
Drain pipe for turbid water
C
View from above
Storage tank
Storage tank for
pasteurized sludge
B
Pasteurization plant
A
Engine room
D
Curved screen with
grinding accessory
Washing and concentration basin
Section C-D
(Paddles not illustrated)
Protective pipe and
guide tube for lead screw
Drainage
channel
Covered passage for
machinery
Jointed outflow
pipe for turbid water

FIGURE 7. Structure of secondary concentration tank

The very cautious estimates of fresh-sludge pasteurization as opposed to the digested-sludge procedure justify the assumption that the cost difference is definitely in favor of fresh-sludge reclamation.

Since sludge concentration is very important in the wet disposal procedure, the construction and operation of the wet concentration tank of Group Sewage-Plant I should be described with the aid of a few illustrations.

Figure 6 shows a model of this installation; Figure 7, the view from above and the cross section of the construction.

The concentration tanks have a total capacity of 4,000 m³, the storage tanks 1,600 m³. Details of operation and results are given in the afore-mentioned article in GWF, No. 16, 1957. In concentration the sludge is not only reduced quantitatively, but also adequately buffered and thus homogenized. The latter is evident from Figure 8.

In this connection we should mention that the alkalinity of the digested sludge is reduced by about half in the process of concentration and washing. Finally, it should be pointed out that for wet disposal a storage tank is indispensable as it acts as a buffer. The 1,600 m³ storage tank connected with the secondary concentration tank was found adequate and expedient in practice.

Figure 8. [illegible] concentration tank

SYNOPSIS OF THE DISCUSSION

By Dr. W. Obrist, EAWAG, Zurich

1. Problems concerning human and veterinary hygiene

Prof. Hess, of the Faculty of Vet. Med. of the Zurich University, considers the described methods of sewage-sludge pasteurization a solution to pressing problems. The following frequency of tapeworm and Salmonella infection was recorded in the animal stock of Switzerland: tapeworm larvae were found incysted in 7.5% of the 21,000 heads of native cattle brought to the Zurich slaughterhouse, in the year 1964; of these, 1.8% had live larvae and 5.7% dead larvae. Larvae of Taenia solium (Cysticercus cellulosae) formerly recorded in masses in pigs have now almost disappeared, since the animals no longer have access to human excreta. Salmonellosis among cattle is very limited, but rather widespread in pigs, among which 9.8% are carriers, although the bacilli were recovered from the feces of only 3.2%. Human infection with Salmonella has trebled in the years 1956–1966. Interruption of the life-cycle of the pathogenic agents by reliable processing of sewage is therefore most desirable. Elimination of worm eggs from sewage is still problematic, since according to Poch (Berlin) Taenia eggs may be found even in appropriately processed domestic sewage, on account of the exceptionally low sinking speed of these eggs.

Prof. Kaestli, President of the Swiss Milk Commission, expressed his satisfaction with the serious thought given to sewage disposal and the efforts made to prevent the spread of various pathogenic agencies. The standing rule of the Milk Commission, in force since 1954, provides that well digested sewage sludge may be disposed in the pastures only in winter. If the hygienic hazards are eliminated by pasteurization sludge disposal in pastures may be allowed also during the vegetation period. Great care should then still be taken in the disposal of domestic and animal sewage and wastes of isolated farms, in order to prevent infestation of the green fodder and, consequently, of the cattle and milk.

Additional questions and remarks: Prof. Liebmann demands that pasteurization proceed for 25 minutes at 70°C. Pasteurization is always a time-temperature correlation. The milk and food industries have adopted the following procedures

30 minutes	at	63—65°C, prolonged pasteurization
15 seconds	at	72—75°C, short-time heating
a few seconds	at	85°, instant pasteurization.

At these temperatures all pathogenic germs, apart from sporogenes, are destroyed. In order to kill the sporogenes a temperature of 110°C should be maintained for 20 minutes. We have heard here that worm eggs are killed within 4 minutes at 70 °C. Why these different conditions in sludge? Does heat penetrate less? Are the official pasteurization temperatures of 65° for 30 minutes, or 72°C for one minute, not applicable?

Another question refers to pasteurization and heating control. In the milk industry the simple phosphatase test is the rule. The phosphatase enzyme is inactivated by the pasteurization temperature. It would therefore be interesting to know whether phosphatase is present in the sludge; if so, it might prove a most valuable control. In addition, there is the Coli test. As known, the Coli bacilli are destroyed by the pasteurization temperatures and so are Salmonella.

Third question: Is it possible to introduce pasteurization recorders? This might also provide a suitable control system.

A few words in connection with the liquid manure. Some maintain that it is absurd to free the sludge of germs, while the nonpasteurized germ-carrying liquid manure from small farms is freely disposed in the pastures. This seems inconsistent, but two aspects should be taken into account: first, utilization of liquid manure in dairy farming is a necessary evil which should not be supplemented by a second. In epidemiology the decisive factor is the quantitative proportion, the degree of contamination: "I am ready to swallow 200 salmonellas but not 2 millions." On farms the ratio of human feces to that of animals is 1 : 100. In sewage sludge it may rise to 1 : 1, thus greatly increasing the chances of infection. Second, if Salmonella contamination occurs on a farm, the danger is localized, whereas with the common disposal of sewage sludge the focus of infection cannot be determined. Therefore, purification of sewage sludge should continue, while purification of liquid manure on the farms, unfortunately, does not seem feasible in the next thirty years.

Fourth question: What is the situation regarding capacity of sludge uptake of the agricultural areas? Given the great amount of liquid manure at our disposal, the required supplement is certainly smaller than in the German areas shown in the film. Calcium, phosphorus and nitrogen are especially valuable but the rural areas will not be able to cope with the inflow of sewage sludge from the large urban concentrations. With increased mechanization the situation may improve, although progress in this direction is not very rapid.

Further question: How long do salmonellas remain viable in the soil and on plants? Is an interval of 3 – 4 months sufficient between sludge disposal and grazing? A rule should be established, because with the new harvesting methods soil may become mixed with the grass. Could that not lead to butiric acid swelling in cheese? From own experiments this danger is remote. And a technical question: Is it possible to add a pasteurization plant direct to the existing sewage works?

Prof. Liebmann states that the sinking speed of different tapeworms varies greatly. According to Poch (Berlin) 100% sedimentation of Taenia eggs, to which the tapeworms of cattle belong, cannot be achieved within the usual time of 1.5 – 2 hours, in highly underloaded or overloaded sedimentation tanks. Even in the normally loaded domestic sewage works only 70 – 90% of the Taenia eggs settle within this time, while 100% sedimentation of ascarid eggs is recorded. Detergents have a particularly adverse effect on the sinking speed. Flocculation means would be appropriate in this case, but the high price of these would aggravate the sludge problem.

To the question of pasteurization time: short periods are generally aimed at, but the heterogeneous sludge mixture may contain fatty-viscous detrital flakes in which the salmonellas cannot be annihilated. Hence, the pasteurization time of 20 – 25 minutes has been adopted on the basis of past experience, although it may be shortened in future, following further testing.

To the question of control: in routine examinations the Coli test should prove adequate. An automatic temperature recorder can be added. Thus, the phosphatase test could be eliminated in view of the fluctuating composition of the sludge for which this test is less appropriate.

To the problem of liquid manure: the aim of separating domestic sewage from animal sewage should always be borne in mind, although this is likely to be a long-drawn out process. It is particularly important in tourist traffic areas where hygienic conditions could be improved by retaining the liquid manure in the septic tank for longer periods.

The problem of sewage-sludge disposal is actually more acute in medium-size communities than in large towns. This, however, does not imply that the sewage can be disposed of economically in large towns.

Dr. Braun raises the question whether the increased incidence of worm infections is caused by the sludge or liquid manure, and whether actual cases are known of illness induced by digested sludge.

Prof. Hess cannot answer the question. Taking into account the high resistence of Taenia eggs, the importance of disrupting the man–animal cycle is evident. Just as pig cysticercosis, formerly so frequent, has almost disappeared, the cattle cysticercosis should also be brought under control.

Prof. Liebmann also advises separation of human and animal sewage. In answer to Dr. Braun's question it can be stated that analyses carried out in the Allgäu and in Middle Franconia show that mixing of human sewage with liquid manure and disposal of the mixture in the meadows has caused an increase of cysticercosis.

Dr. Braun concludes from the answer that no actual cases of infection are known to have been caused by digested sludge.

Prof. Kaestli is rather cautious since the epidemics can never be accurately localized. According to certain data from England, typhoid epidemics have been caused by bacilli originating in the sewage sludge and disseminated by milk.

Prof. Wuhrmann advocates pasteurization of sludge wherever possible, while suggesting that disposal of unpasteurized, well digested sludge be permitted as before, but not in the vegetation period.

Question 1. Are there other sporogenes to be taken into account that might close the chain of infection so that more severe measures might be imposed on sludge purification in future, or is pasteurization regarded as adequate?

Question 2. How do worm eggs behave in sewage works? Is there danger that in mechanical-biological plants, too, the light eggs will be washed away into the outfall ditch?

Prof. Kaestli states that there are no sporogenes to be afraid of, so that no sterilization is ever necessary.

Prof. Hess is of the same opinion and adds that anthrax bacilli are only very rarely found in Switzerland, although their viability in soil lasts a minimum of 45 years.

Prof. Liebmann. with regard to anthrax, the same is true for the Federal Republic. Nevertheless, the leather industries should be warned that in view of the expanding commercial relations with East-European countries, the danger is increasing again. Therefore, sewage and sludge from leather industries should not be disposed in agricultural areas.

Concerning the Taenia eggs: In normally loaded sewage works the majority of worm eggs is retained, while some viable eggs escape. A 100% sedimentation is not necessary if the man—animal cycle is disrupted by adequate separation of human feces from animal feces. In plants with biological processing 90% of escaped eggs are recaptured, so that the problem is practically solved.

Dr. Braun enquires whether the aerobically treated sludge belongs to the fresh or the digested category. May the aerobically stabilized sludge be disposed in the pastures in winter, or not?

Prof. Liebmann suggests that this sludge be considered fresh sludge and that it always be pasteurized.

Dr. Braun returns to the problem of liquid manure. With the numerous isolated settlements, farmsteads, country hotels and vacation homes in Switzerland, would it be possible to discharge the liquid manure in all instances in the nearest sewage works. What are the prospects of pasteurization of this liquid manure, considering that it cannot be disposed throughout the year? Would it be possible to have mobile pasteurization plants?

Prof. Liebmann's opinion is that individual pasteurization plants are out of the question. But in such cases a three-chambered cesspool should be built, large enough to allow for a three-month digestion period. The digested sewage could then be disposed in the open, in winter.

Dr. Märki enquires about the source of the Salmonella increase, considering that the man-pig chain has been disrupted by the new pig breeding regulations.

Question 2. A large milk association confirmed that no damage was recorded during the 30 years in which the firm has applied large amounts of digested sludge to the pastures. How then could pasteurization be made palatable to communities when it involves costs of up to Fr 5/m^3 sludge? Considering that overall pasteurization of milk has not been achieved in Switzerland, the chances of sludge pasteurization seem rather slim.

Prof. Hess suggests that the infection source may be found in the imported feeds. In answer to the second question, it is an established fact that the number of tapeworm carriers has increased. Unfortunately, there are no accurate figures since worm infections need not be reported. Since carriers eject up to 400,000 eggs per day, they should be detected. We would not let salmonellosis advance so far as happened in a certain country where, in 1954, 10,000 cases of typhoid were reported from meat consumption. There, the cycle man–animal was continuous, and we would like to protect our consumers from this.

Prof. Liebmann contributes the following: 45 – 50% of the calves delivered to the slaughterhouses in Central Europe are infected with Ascaris vitulorum. From a certain degree of infestation onward the metabolites of ascarid contain butyric acid which is stored in the striated muscles of the calves so that the meat cannot be accepted as fresh but must be seasoned and made into sausages, whereby the meat price is lowered by 20 to 30%. In cows infested with ascarids the milk yield is reduced. These losses are greater than the costs of reasonable pasteurization.

Prof. Kaestli is interested in the question of responsibility. If milk epidemics can be traced back to contamination from sludge, the milk consumption can be unfavorably affected. In the region of the aforementioned company the milk contamination spread from a certain farm. When epidemics break out the exact percentage of losses is less important than the question of responsibility of the proper authority.

2. Technical, organizational and economic problems

Eng. Wuhrmann would like to know whether beside pasteurization other procedures were contemplated, especially whether radiation has any prospect.

Prof. Liebmann is in a position to state that alone the running expenses of purification by radiation for 100,000 inhabitants will amount to 1.5 to 2 million DM per year. This astronomic figure will be spent mostly on the elimination of high irradiation doses. In connection with sludge disposal it should be mentioned that in Bavaria disposal of digested sludge in the open, in winter, has been practiced for many years without any damage being caused by viruses, bacteria or worm eggs. However, there are more and more instances of digestion time not being strictly adhered to, or feces of man and animals being mixed. In such cases, as in sludge-stabilizing plants, pasteurization is imperative.

Prof. Wuhrmann raises again the problem of liquid manure. Since, according to Prof. Liebmann, the material should be left to digest for three months, and disposal performed in winter, the storage capacity required per inhabitant would be 18 m^3. This being practically impossible, the question is whether transfer of the cesspool contents from isolated houses to existing sewage works could solve the problem.

The partially practiced obligation of disposing the domestic sewage in agricultural areas is no permanent solution.

Ing. Guldenmann: Some sedimentation plants in the Basel-Land Canton accept sludge from individual cesspools (domestic and animal). These additions with their odors cause irritation to and discontent among the servicing personnel. At first, addition of the sludge caused some disturbances in the digestion tank. Now, the sludge is put directly into the feeder.

Ing. Colombe: In certain areas of the Waadt Canton individual cesspools are emptied by private firms. For disposal, there are two possibilities: either sewage works, or abandoned clay pits, which are absolutely impermeable.

Prof. Wuhrmann inquires about the accepted time and temperature of pasteurization, and whether fresh sludge must be homogenized first.

Building Director Triebel is all in favour of prolonged heating at low temperatures, i.e., 30 minutes at 65 – 70°C. In order to prevent clumping and packing in the course of pasteurization, the sludge is run over drip pans under steam inflow. Since operation proceeds with the sewer gas generated in the process and hence without cost, and since heat is recuperated, the final expense amounts to approximately 0.60 DM, capital cost included. Homogenization is essential. In the course of adequate digestion and secondary concentration the sludge is well homogenized, whereas fresh sludge requires additional stirrers and more rigorous conditions of pasteurization.

Dr. Roediger would suggest both higher temperatures and longer periods of time, i.e., minimum 70°C or even 85°C, since gas is available. Fresh sludge can be homogenized by mixers.

Building Director Triebel: Homogenization may be required also with digested sludge, or textiles and other coarse components should be removed in order to prevent blocking of the pasteurization plant. In addition the sludge structure is improved by homogenization so that a triple gain is subsequently obtained upon filtration. In order to compensate for a possible lack of gas, reserve oil-heating should be provided.

Mr. Kinsel deals with the problem of settlements not connected with sewage plants, and which in the year 1970 will represent approximately 40% of the Swiss settlements. This sewage must be removed and, where possible, purified on the spot. Since mobile appliances are technically not possible, centralization of sewage purification should be aimed at.

Building Director Triebel reports that the temperature of the sludge drops by 8°C while it is spread in the open, wherefore the temperature at the time of loading should not exceed 38°C. The storage tanks should be correspondingly large, which is of no importance economically.

Demand: each customer receives from the Niersverband only 2 cm sludge per year, and must order it months in advance. Thus, no disposal difficulties were experienced in two rainy summers. For control, the Ministry was asked to sample the material at any time it pleased.

Dr. Braun: How should the domestic sewage be handled in sites devoid of canalization connected to sewage works? Should regional collection sites be installed and the large containers subsequently pasteurized?

Prof. Liebmann knows the calculations published by Ing. Imhoff, jun., according to which transport is worthwhile within a radius of 25 – 30 km (in the conditions prevailing in Germany). If no sewage works exist within this radius, a collection center with a pasteurization plant should be established at an appropriate site and transport from isolated settlements should be made compulsory.

Dipl. Ing. Baldinger, Director of the Federal Bureau for the Protection of Waters, doubts whether Prof. Liebmann's suggestions can be put into practice. Since all communities must build sewage works, there is no inclination towards temporary solutions.

We must take into account a certain time of transition. The drainage network should be as dense as possible, in order to convey to the central purification plant as much sewage as possible in the shortest possible time, instead of extensive drainage areas that will still not be sewered in the next 10 to 30 years. The scattered building system should be replaced by appropriate planning and the construction of small purification plants limited.

Prof. Kaestli agrees that planning should take into account development in the distant future. But the time has come to act according to our views, especially as regards individual settlements.

Prof. Wuhrmann: Does pasteurization change the consistency of sludge, as for example its properties of concentration and dewatering? How does undigested sludge behave in the fields? What are the expenses involved in the pasteurization of fresh and digested sludge?

Building Director Triebel, who operates only one sewage plant equipped with pasteurization facilities, is sure that processing of fresh sludge is preferable. The nuisance of bad odors is minimized. After three days, no trace is left of the 2-cm thick sludge in the meadows, although it is visible in the soil crumbs.

Dr. Roediger cannot foresee the subsequent behavior of the fresh sludge. Presumably, its disposal in thin layers should be possible.

Dr. Braun: How large should the sewage works be in order to justify, economically, a pasteurization plant? Is the cost of Fr 2/m^3 wet sludge correct, and what should be the minimum population for justifying a sludge pasteurization plant?

Dr. Roediger: Building expenses for a population equivalent of 20,000 amounts to about Fr. 1. The population equivalent should be 15,000 to 20,000 minimum.

Ing. Hammerli: What is the amount of fresh water required for one m^3 sludge per hour?

Ing. Peil: The Niersverband uses, with heat recuperation, approximately 0,9 t steam for 17.5 m^3 sludge. The operation proceeds under vacuum and the vapors are again brought together with the unheated sludge.

Dr. Geering, of the Federal Agricultural Experimental Station, Zurich-Oerlikon, has experienced rather disastrous results with filtered fresh sludge in corn fields for fodder. What are the results with pasteurized sludge?

Building Director Triebel reports satisfactory results with small doses. Dosage is important. Nevertheless, yields proved quite good even after dressing with high doses, when low ground was experimentally filled.

Director Baldinger thanks Professor Jaag on behalf of the **Federal institutions** represented for the initiative and invitation to the symposium, and also expresses his thanks to the lecturers and all participants.

LITERATURE RECEIVED BY THE SECRETARIAT

Banse, H.-J., G. Farkasdi, K.-H. Knoll, and D. Strauch. Kompostierung von Siedlungsabfällen (Composting of Settlement Refuse). — Der Städtetag, Issue 7. 1967.

Barth, H. and F.-W. Brauss. Untersuchungen zur Hygiene der Schnellkompostierung nach dem Multibacto-Verfahren (Hygienic Evaluation of the Multibacto Rapid Composting Process). — Städtehygiene, Issue 4. 1967.

Betz, F. W. Untersuchung verschiedener Transportsysteme beim Ferntransport von Müll (Examination of Various Transport Systems in Long-Distance Transport of Refuse). — Der Städtetag, Issue 5. 1967.

Blanc, J.-L. Le procédé de deshydratation des boues, système Porteous. – Wasser, Boden, Luft; - Schutz des Lebensraumes. Verlag A. Grob AG, St. Gallen. 1967.

Böhme, L. Wie Müllkomposte auf landwirtschaftliche Kulturen wirken (Effect of Refuse Composts on Crops). – Die örtliche Versorgungswirtschaft, Issue 2, 3rd year of publ., Dresden. 1967.

Bopp, R. Bewertung von Müllverbrennungsanlagen auf Grund der Erstellungs- und Jahreskosten (Evaluation of Waste Incineration Plants on the Basis of Investment and Annual Operating Costs). –Aufbereitungs-Technik, No. 5. 1967.

Braun, R. Probleme und Möglichkeiten der Klärschlammbeseitigung (Problems and Possibilities of Sewage-Sludge Disposal). – Schweizer Journal, No. 3. 1967.

Burger, G. Möglichkeiten und Grenzen der Entseuchung infektiöser Siedlungsabfälle auf dem Wege der aeroben Kompostierung (Possibilities and Limitations of Disinfecting Infective Settlement Refuse by Aerobic Composting). – Zeitschrift für die gesamte Hygiene und ihrer Grenzgebiete, 11th year of publ., Issue 6. 1965.

Burger, G. Hygienische Empfehlungen zur Planung von Kompostierungsbetrieben (Hygienic Recommendations for the Planning of Composting Plants). – Zeitschrift für die gesamte Hygiene und ihrer Grenzgebiete, 13th year of publ., Issue 4. 1967.

Burger, G. Untersuchungen zur Kompostierung von Siedlungsabfällen in Rottekammern (Examinations Concerning the Composting of Settlement Refuse in Digestion Tanks). – Zeitschrift für die gesamte Hygiene und ihrer Grenzgebiete, 13th year of publ., Issue 3. 1967.

Buser, A. Bemühungen für die Gesundung der Limmat im Raume Baden (Efforts at the Sanitation of the Limmat in the Baden Area). – Wasser, Boden, Luft; Schutz des menschlichen Lebensraumes. Verlag A. Grob AG, St. Gallen. 1967.

Caruel, R. L'utilisation des sacs en papier pour la collecte des ordures ménagères à Marseille. – Techniques et Sciences Municipales, 62nd year of publ., No. 3, Paris. 1967.

Döll, H. Städtehygiene in der Antike (Town Hygiene in Antiquity). – Städtehygiene, Issue 1. 1967.

Doose. Probleme bei der Verbrennung von Abfällen (Problems Attending Refuse Incineration). – Der Städtetag, Issue 6. 1967.

Duhme, W. Müllverbrennungsanlage für Hagen (Refuse Incineration Plant in Hagen). – Der Städtetag, Issue 3. 1967.

Flon, H. and F. Ferrari. Le besoin en humus des sols et le compostage des ordures ménagères dans le département de Seine-et-Marne. – Techniques et Sciences Municipales, No. 5, Paris. 1967.

Fröhner, K. Satzung über die öffentliche Müllabfuhr (Rules Concerning Public Waste Removal). – Der Städtetag, Issue 3. 1967.

Fuhrimann, H. Zur Heissvergärung von Schlachtabfällen (Hot Fermentation of Slaughterhouse Refuse). – SVZ, Schlacht- und Viehhof-Zeitung, Issue 4, 67th year of publ., Brücke-Verlag Kurt Schmersow, Hannover. 1967.

Giger, R. Ausbau der Kehrichtanlage Werdenberg-Liechtenstein in Buchs/SG (Extension of the Refuse Plant Werdenberg-Liechtenstein in Buchs/SG). – Plan, No. 2. 1967.

Haenert, F. Industrieabfalle in kommunalen Verbrennungsanlangen (Industrial Waste in Communal Incineration Plants). – Müll, Abfall, Abwasser, Issue 3. Verlag A. Schweiger, 516 Düren. 1966.

Hirschheydt, v. A. Zur Frage der Müllkompostierung (On Refuse Composting). – Kommunalwirtschaft, Issue 1. 1967.

Houter, P. J. and D. W. Stolp. Der Verkauf von Kompost von städtischen Abfällen in den Niederlanden (Sale of Compost from Urban Refuse in the Netherlands). – Lecture IX Internat. Congress of INTAPUC, Paris. 1967.

Jäger, B. Gemeinsame Behandlung von Abfallstoffen verschiedener Herkunft (Joint Processing of Refuse from Different Sources). – Kommunalwirtschaft, Issue 1. 1967.

Kampschulte, J. Stand des Anfalls und der Beseitigung von Haus- und Sperrmüll in der Bundesrepublik Deutschland (Yield and Disposal of Domestic and Bulky Refuse in the German Federal Republic). – Müll, Abfall, Abwasser, Issue 3, Verlag A. Schweiger, 516 Düren. 1966.

Kaupert, W. Müllverbrennung mit Wärmeverwertung (Refuse Incineration with Heat Utilization). – Lecture IX Internat. Congress of INTAPUC, Paris. 1967.

Kehren, L. Les compostages des ordures ménagères dans les pays chauds. – Techniques et Sciences Municipales, No. 5, Paris. 1967.

Klaus, H. Heutiger Stand der Strassenreinigungstechnik (Present State of Street-Cleaning Techniques). – Kommunalwirtschaft, Issue 1. 1967.

Knoll, K. H. Gegenwärtiger Stand der hygienisch einwandfreien Beseitigung fester und flüssiger Siedlungsabfälle unter besonderer Berücksichtigung der Kompostierung (Present State of Hygienically Safe Disposal of Solid and Liquid Settlement Wastes, Especially in Relation to Composting). – Städtehygiene, Issue 2. 1967.

Koppernock, F. and G. Thomas. Eine neue grosse Abwasser- und Schlammaufbereitungsanlage; Die Hauptkläranlage der Fa. E. Merk AG. Darmstadt (A New Large Plant for Processing Sewage and Sludge; The Main Purification Plant of E. Merk AG, Darmstadt). – Müll, Abfall, Abwasser, Issue 4, Verlag A. Schweiger, 516 Düren. 1967.

La. Müllverbrennungsanlage Frankfurt a. M. (Waste Incineration Plant in Frankfurt a. M.). – Bauen und Wohnen, Zurich, Issue 3. 1967.

La. Kehrichtverbrennungsanlage Basel (Refuse Incineration Plant of Basel). – Bauen und Wohnen, Zurich, Issue 3. 1967

La. Müllverbrennungsanlage Nürnberg (Waste Incineration Plant of Nürnberg). – Bauen und Wohnen, Zurich, Issue 3. 1967.

Lammert, P. Les Cheneviers Müllverbrennungsanlage, Genf (Waste Incineration Plant Les Cheneviers of Geneva). – Bauen und Wohnen, Zurich, Issue 3. 1967.

Lancoud, F. Les Cheneviers- Usine d' incinération des résidus de la ville de Genève. – Schriftenreihe der Schweiz. Vereinigung für Gesundheitstechnik, Zurich, Issue 4. 1967.

Lausten. Müllgaswerk in Kolding (Waste Gasworks in Kolding). – Der Städtetag, Issue 6. 1967.

Lehni, H. Die neue Verbrennungsanlage für ölhaltige Abfälle im Kanton Luzern (The New Incineration Plant for Oil-Containing Wastes in the Lucerne Canton). – Wasser, Boden, Luft - Schutz des menschlichen Lebensraumes. Verlag A. Grob AG, St. Gallen. 1967.

Littmann, D. and J. Krings. Die technische und bauliche Konzeption von Müllverbrennungsanlagen (The Technical and Structural Concept of Waste-Incineration Plants). – Bauen und Wohnen, Zurich, Issue 3. 1967.

Mahlke, H. Rationalisierung bei Strassenreinigung und Müllabfuhr (Rationalization in Street Cleaning and Waste Disposal). – Der Städtetag, issue 6. 1967.

Mayer, H. G. Die Oelschlammverbrennungsanlage München-Grosslappen (The Oil Sludge Incineration Plant of Munich-Grosslappen). – Der Städtetag, Issue 4. 1967.

Mayrle, I. Mehrzweck-Transportgerät zur Verwendung für die Müllabfuhr in ländlichen Gegenden (Multipurpose Transport Equipment for Waste Removal In Rural Areas). – Städtehygiene, Issue 12. 1966.

Merkel, W. and W. Merkel. Neuentwicklungen des Schlammbelebungsverfahrens? (Developments in Activated-Sludge Processing?). – Städtereinigung, Issue 2. 1967.

Mesnil, M. and G. Baguenier. L'évacuation et le traitement des résidus urbains. – Techniques et Sciences Municipales, Paris, No. 5. 1967.

Michaels, A. Verbrennung der Siedlungsabfälle ohne Wärmeverwertung (Incineration of Settlement Refuse without Heat Utilization). – Lecture IX Internat. Congress of INTAPUC, Paris. 1967.

Mischerikow, K. Die Anwendung von Multiplikatoren in der Kalkulation der System-Hausmüllabfuhr bei unterschiedlichen Gefäss-Transportwegen (Use of Multipliers in the Calculation of the Domestic Waste-Removal System when Different Means of Transport and Vessels are Used). – Der Städtetag, Issue 4. 1967.

Möller, U. Zur Technologie der Schlammentwässerung (Contribution to the Technology of Sludge Dewatering). – Städtehygiene, Issue 3. 1967.

Moser, E. Massnahmen zur Verhinderung von Luftverunreinigungen bei Kehrichtverbrennungsanlagen (Control Measures against Air Pollution by Refuse Incineration Plants). – Schriftenreihe der Schweiz. Vereinigung f. Gesundheitstechnik, Zurich, Issue 4. 1967.

Mudrack, K. Sind Abwasser- und Schlamm-Untersuchungen auf Kläranlagen notwending oder möglich? (Are Examinations of Waste-Water and Sludge in Clarification Plants Necessary or Possible?). – Städtehygiene, Issue 1. 1967.

Müller, H.-J. Müllverbrennungsanlagen nach dem Baukastensystem (Unit Waste Incineration Plants). – Kommunalwirtschaft, Issue 1. 1967.

Netzel, G. 15 Jahre Fortschritt in der Abwasserschlamm-Entwässerung (Fifteen Years of Progress in the Dewatering of Sewage Sludge). – Städtehygiene, Issue 11. 1966.

Netzel, G. 15 Jahre Fortschritt in der Abwasserschlamm-Entwässerung (Fifteen Years of Progress in the Dewatering of Sewage Sludge). – Müll. Abfall Abwasser, Issue 4, Verl. A. Schweiger, 516 Düren. 1967.

Novak, B. Einfluss der Substratqualität und des Aerationsgrades auf die Humifizierung der organischen Stoffe (Effect of the Substrate and Degree of Aeration on the Humification of Organic Matter). – Tagungsbericht No. 82, Teil II, Arbeitskreis Ertragsbildung und Bodenfruchtbarkeit, Deutsche Akademie der Landwirtschaftswissenschaften zu Berlin. 1966.

Nowak, F. Erfahrungen an der Müllverbrennungsanlage Stuttgart (Practical Experience with the Waste Incineration Plant in Stuttgart). – Brennstoff-Wärme-Kraft, Vol. 19, No. 2. 1967.

Ochs, H.-J. Die Problematik der Erfassung verschiedener Industriestäube (Problems of Dust Trapping in Various Industries). – Müll, Abfall, Abwasser, Issue 4, Verl. A. Schweiger, 516 Düren. 1967.

Orth, H. Sammelfahrzeuge für die Müllabfuhr (Collecting Vehicles for Waste Removal). – Vortrag 6. Mulltechn. Kolloquium 1965 an der T. H. Stuttgart. Verb. Kommunaler Fuhrparks- und Stadtreinigungsbetriebe VKF, Frankfurt a. M. 1965.

Palm, R. Trommelöfen für die Abfallverfeuerung (Rotary Furnaces for Waste Incineration). – Aufbereitungs-Technik, Issue 12. 1966.

Perl, K. Anlagendiagramm für eine Müllverbrennung (Layout of a Waste Incineration Plant). – Energie, Zeitschrift f. praktische Energietechnik, 19th year of publ., Issue 2, München. 1967.

Riedlinger, R. A. Grossanlage zur Müllverbrennung in Düsseldorf (Large Waste Incineration Plant in Düsseldorf). – Der Städtetag, Issue 3. 1967.

Risch, P. Die Notwendigkeit zweckmässiger Lösungen der Wasser-, Abwasser- und Kehrichtprobleme unserer Fremdenverkehrsgebiete (The Urgency of Solving the Problems of Water, Sewage and Refuse in Tourist Areas). – Wasser, Boden, Luft, - Schutz des menschlichen Lebensraumes. Verl. A. Grob AG, St. Gallen. 1967.

Roediger, H. Schlammaufbereitung mit oder ohne Faulung? (Sludge Treatment with or without Digestion?). – Gas- und Wasserfach; Wasser - Abwasser, 108th year of publ., Issue 18. 1967.

Rohrer, E. Verwertung der Abfälle der Müllkompostierung (Utilization of Refuse-Composting Wastes). – Chemische Rundschau of 19 April 1967, Solothurn. 1967.

Rossow, W. Verarbeitung der Stadtabfälle (Processing of Urban Wastes). – Bauen und Wohnen, Zurich, Issue 3.

Roullet, P. and J. Jullien. La nouvelle usine d'incinération d'Issy-les-Moulineaux. – Techniques et Sciences Municipales, Paris, No. 5. 1967.

Schwarzenbach, F. Weitere praktische Erfahrungen mit dem Müll-Papiersack (Further Experience Gained with Paper Bags for Garbage). – Städtehygiene, Issue 4. 1967.

Spohn, E. Was ist Kompost? (What is Compost?). – Organischer Landbau, No. 1. 1967.

Spohn, E. Ist Müllverarbeitung eine kommunale Aufgabe? (Is Refuse Processing a Municipal Task?). – Kommunalwirtschaft, Issue 1. 1967.

Stauffer, H. F. Neue Wege in der Klärschlammverarbeitung (New Trends in Sewage-Sludge Processing). – Städtehygiene, Issue 3. 1967.

Stickelberger, D. Ueber die Wirkungweise von Stadt-Komposten und die Rentabilität bei deren Anwendung (Effect of Urban Composts and Profitability of Their Utilization). – Schriftenreihe Aufbereitung und Nutzbarmachung von Siedlungsabfällen, Issue 2, Voith Müllex GmbH, 7920 Heidenheim. 1967.

Straub, H. Grundsatzfragen bei der Beseitigung von Siedlungsabfällen (Fundamental Questions in Connection with Refuse Disposal in Settlements). – Der Städtetag, Issue 7. 1967.

Straub, H. Der technische Stand der Behandlung von Siedlungsabfällen im Hinblick auf ihre landwirtschafttliche Verwertung (The Technical Position of Settlement-Waste Treatment in Relation to Its Reclamation for Agriculture). – Lecture IX Internat. Congress of INTAPUC, Paris. 1967.

Strauch, D. Internationaler Erkenntnisstand in den Fragen der Hygiene der Müllbeseitigung (International Knowledge of the Problems Involved in the Hygiene of Refuse Disposal). – Stuttgarter Berichte zur Siedlungswasserwirtschaft, Vol. 27, Verl. R. Oldenbourg, München. 1967.

Sumner, J. Unterbringung und Abfuhr des Mülls; Methoden, Verfahren, technische Entwicklungen und Tendenzen; Untersuchung im internationalen Rahmen (Collection and Removal of Refuse; Methods, Treatment, Technical Developments and Trends; Inquiry on an International Scale). – Lecture IX Internat. Congress of INTAPUC, Paris. 1967.

Tenaille, G. Le traitement des ordures ménagères de la région de Versailles. – Techniques et Sciences Municipales, Paris, No. 6. 1967.

Tepe, W., E. Leidenfrost, and A. Darlowsky. Einsatz von Schnellmethoden an Müll-Klärschlammkomposten zur Ueberprüfung des Rotteverlaufes (Introduction of Rapid Methods for the Verification of Digestion Progress in Compost of Refuse and Sewage Sludge). – Müll, Abfall, Abwasser, Issue 4, Verlag A. Schweiger, 516 Düren. 1967.

74. Universidade de Sao Paolo. O Problema do Lixo no Meio Urbano. – Seminario, Faculdade de Higiene e Saude Publica, Universidade de Sao Paolo, Brasil. 1965.

75. Weibel, R. Korrosionsschutz bezw. Anstrichprobleme bei Kehrichtbeseitigungs- und Abwasserkläranlagen (Problems of Corrosion Prevention and Paint Coats in Waste Disposal and Sewage Treatment Plants). – Wasser, Boden, Luft - Schutz des menschlichen Lebensraumes, Verl. A. Grob AG, St. Gallen. 1967.

76. Weidner, J. Kompostierung fester und flüssiger Siedlungsabfälle (Composting of Solid and Liquid Settlement Wastes). – Bauen und Wohnen, Zurich, Issue 3. 1967.

77. Wiesli, H. Sind wir auf dem richtigen Weg? Gedanken zur Abfallbeseitigung (Are We on the Right Path? Ideas Concerning Refuse Disposal). – Wasser, Boden, Luft; Schutz des menschlichen Lebensraumes. Verl. A. Grob AG, St. Gallen. 1967.

78. Wuhrmann, K. A. Was leistet eine Müllbehandlungsanlage?(What Does a Refuse-Processing Plant Yield?"). – Aufbereitungs-Technik, 8th year of publ., Wiesbaden, Issue 5. 1967.

79. Wuhrmann, K. A. Die Bedeutung der geordneten Deponie (The Importance of Controlled Tipping). – Der Städtetag, Issue 6. 1967.

80. Wuhrmann, K. A. Einige Merkmale der Müllbeseitigung in den USA (Some Features of Refuse Disposal in U.S.A.). – Städtereinigung, Issue 2. 1967.

81. Wüthrich, F. C. Der Einfluss von Transportkosten des Mülls auf Grösse und Standort der Müllverbrennungsanlagen (Effect of Transport Costs on the Size and Location of Refuse Incineration Plants). – Plan No. 1 1967.

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BLOOD-FORMING EFFECT OF REFUSE COMPOST ON SUCKING PIGS

By Ing. B. Teensma, Amsterdam

At the "Centraal Diergeneeskundig Institut" in Rotterdam in 1958 – 1966 various ferric preparations, including finely sifted refuse compost, were tested for their blood-forming effect on sucking pigs. The test results were published by the authors, Dr. J. P. W. M. Akkermans and Dr. J. C. Baars, in "Tijdschrift voor Diergeneeskunde," Vol. 92, No. 12 of 15 June 1967, under the title "De profylaxe van bloedarmoede bij biggen" (Prophylaxis for Anemia in Pigs). The following findings were taken from this paper.

Problem

In modern pig-breeding, animals do not run freely, and the Netherlands' breeding establishments find that anemia occurs in sucking pigs with increasing frequency. The cause is lack of iron, which young pigs growing up wild find in sufficient quantities because they have free access to pastures and often eat soil. A newly-born pig has about 50 mg of iron in store, of which it needs about 7 mg daily for the first few days after birth. After 14 days, the requirement rises to about 15 mg daily, and it gets from the mother's milk at the most 1 mg daily, and a further 0.5 mg daily maximum from licking the sty walls, etc. Without an additional iron supply, the piglet will show symptoms of iron deficiency after 7 – 10 days. Preventing such anemia thus became an economic necessity and many tests were made in an attempt to solve it.

Supplying ferric preparations (orally or by injection) to the pregnant sow proved unsuccessful. An attempt was then made to increase the iron content of the sow's milk using iron fumarate. This compound was administered in doses of 2 – 5 g per kg feed for 2 weeks before the litter and up to 8 weeks after. Although the iron content of the sow's milk was thus increased 20 – 100%, this was not sufficient. In sows with favorable response to this method of increasing iron content, the results were probably due to their receiving additional iron from eating mud in the sty. The use of earth in pig sties is difficult, however, leading to soiling, and being hard to obtain during periods of frost. Moreover, iron content of soil is not consistent nor is it always sufficiently high. If it drops below 750 ppm, anemia cannot be prevented; nor can it be prevented when the iron contained in the soil is ferric.

Direct administration of iron to young pigs appears to be expedient. A single injection of 150 – 200 mg iron in the form of iron dextran showed good results with 2 – 4-day old pigs. Disadvantages of this injection are the high price, and the high molecular weight (180,000) of dextran compounds, which may cause violent tissue reactions with ensuing death. "Ironorbitol" compounds with a molecular weight of under 5,000 have no such unpleasant property, but they are also expensive.

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Attempts were made to find effective but inexpensive preparations that could be administered orally, and two groups of materials were found suitable.

1. Preparations that have to be administered orally or by injection.
2. Preparations that are accepted voluntarily.

Forced administration has the practical disadvantages of requiring much work and exciting the animals in the sty. There is also the danger of inhalation pneumonia when an excited animal is force-fed. For this reason, tests were made mainly of preparations which were voluntarily accepted.

Results

A Of iron dextran and iron polysaccharide compounds to be injected, only the preparation "Imposil" (Fe-dextran) showed good results.

B The iron orbitol compound "Jectofer" gave good results initially, but after three weeks the hemoglobin content had dropped.

C Preparations requiring forced oral administration:

1. Effects of "iron-anemia pastes" do not compare well with the effects of "Imposil" and "Jectofer."
2. A mixture of $FeSO_4$ and $CuSO_4$ (Beijers preparation) gave good results, but it has the disadvantage of having to be administered daily for a few days.

D Preparations voluntarily accepted by mouth:

1. Refuse compost
   - a) Compost was gladly accepted from the first day.
   - b) Neither drying, sifting, nor sterilizing the compost lowered its blood-building effect.
   - c) The compost's iron content showed a marked positive effect on the hemoglobin content after one week.
   - d) To prevent anemia, compost should be given from the first day after birth until the young pigs are receiving sufficient additional nourishment (21 – 25 days). If compost is given only during their first week of life, the piglets' hemoglobin content drops rapidly.
   - e) No cases of illness have been observed following the use of compost.
   - f) The metallic iron content of compost has no blood building effect in itself. The effect results from organically and inorganically bound iron content in compost in quantities of 1.5 g to 8 g per 1 kg compost.

Comparison between compost and "Imposil" showed the following results:

Hemoglobin content of blood (mean values)

Age (in days)	4	11	18	25	32	39	46	Number of piglets
Compost	7.92	8.03	9.52	10.72	11.44	11.41	11.38	103
"Imposil"	7.95	9.50	9.73	9.68	9.56	9.74	9.57	70

A higher hemoglobin content can be attained with compost than with a single injection of 150 – 200 mg Fe-dextran.

2. Yeastmeal preparations gave good results but the animals accepted only small quantities of these in their first 14 days of life.
3. "Pigstarters" gave varying results.
4. The "bloodbuilding grains" were not satisfactory because some young pigs did not eat them.
5. Mud from a pond into which tree leaves had fallen, had a marked effect on blood building.

Results concerning the animals' growth: of eight preparations tested, the following four influenced growth:

	Number of animals	Slight retardation	None or only slight effect	Medium or considerable effect
"Imposil"	12	0	9 (75%)	3 (25%)
Compost	15	0	9 (60%)	6 (40%)
Yeastmeal	6	2 (33%)	3 (50%)	1 (17%)
Mud	2	2 (100%)	–	–

In this case, too, the first two preparations listed show the best results.

Conclusions

Prevention of anemia in young pigs has become urgent for the Netherlands' pig-breeding industry. Injections of iron dextran compounds have proved valuable for blood building, but these preparations have the disadvantage of occasionally producing shock which may kill an entire litter within a few hours after administration. The danger of infection is present also, and complaints have been made of spoilage of hams.

Because effective preparations are too expensive, which prevents their wide application, attempts were made to find preparations suitable for oral use and acceptable to piglets spontaneously and immediately after birth. Refuse compost has the properties desired, and is now on sale in attractive packages in the Netherlands, under the name "young pig feed." The product has the disadvantage of a widely varying iron content (1.5 g to 8 g per kg).

Author's postscript

The varying iron content of refuse compost would have to be considered a disadvantage if the young pigs did not receive sufficient iron. In the first three weeks after birth, however, a young pig requires 200 mg iron, and in that period it receives about 2 kg compost, which contains a minimum of 3,000 mg organically and inorganically bound iron. As this is fifteen times the quantity required, even if a portion of the compost is smeared and lost, the animals still receive more than they need, and surplus iron is harmless.

METHODS OF PLANNING AND PREPARING PLANTS FOR PROCESSING OR DISPOSAL OF COMMUNAL REFUSE

By Dipl. Ing. Oec. Gunter Sudhoff, Institut für Kommunalwirtschaft, Dresden (Director Uhlich)

FOREWORD

The continuous increase in the amount and volume of garbage, as well as the disappearance of areas suitable as refuse dumps near towns cause the disposal or utilization of communal refuse to become a serious problem also in the German Democratic Republic (GDR). This imposes completely new tasks on the competent local authorities, where those responsible know only in exceptional cases how to plan and design refuse-utilization plants correctly.

The Institute for Communal Economics (ICE) Dresden is the central research and guidance institute in the field of utilization of communal refuse in the GDR.

If requested by local authorities and after suitable preliminary investigations the Department for the Utilization of Communal Refuse of the ICE Dresden works out recommendations, projects, and technical-economic aims, so as to ensure construction and running-in of refuse-processing plants operating faultlessly at maximum efficiency. Preparatory work is in principle carried out according to the scheme given below. Modifications are introduced in specific cases, depending on the problem to be solved and on local conditions.

The following refers to solid communal refuse, including sewage sludge. The scheme is based on methods of operational research. This provides a simple and clear presentation of the sequence, as well as of the interactions and relationships between the various stages of the work. The circles define events. They denote the arrival or availability of the results of previous work stages. Activities shown as arrows ending or beginning at events define stages of work to be started after the preceding event has occurred and which have to be completed within a predetermined time. They end at the subsequent event.

Broken arrows (e.g., 1 – 3) represent fictitious activities. They require no time, but only indicate that occurrence of the preceding event is a precondition for the start of the activity beginning at the subsequent event.

EXPLANATION OF WORK STAGES

Investigations 0 – 1, 0 – 2, and 0 – 3 are the first tasks undertaken in order to solve the garbage problem. They may be carried out simultaneously.

0 – 1. Investigation of Possibilities and Costs of Controlled Tipping

Controlled Tipping has until now not been considered in investigations of the problem of refuse disposal.*

* The concept "refuse disposal" is here considered from the viewpoint of the refuse "producer," to whom it is unimportant whether his refuse is by means of certain processes transformed into a product of utility, or whether it is dumped. To him it is only important that the refuse is removed from areas of human settlement in such a way that noxious and offensive effects are prevented.

Controlled Tipping has to be included in the study, since on one hand, "free dumping" with its many possibilities of causing nuisance, danger, and damage seriously contravenes the most elementary hygienic and aesthetic requirements, while on the other hand, dumping of communal refuse cannot be dispensed with, since

a) residues remain after composting and burning [of refuse], for which dumps have to be provided.

b) Dumping is necessary where the refuse collected during certain months (e.g., from December to March) or from certain areas (e.g., suburban areas with many gardens where stoves are used for heating) cannot be burnt or composted because of its composition (too low calorific value, too little organic matter).

c) Construction of refuse-processing plants requires capital and time for preparation. Controlled Tipping is to be employed as a temporary measure until the compost or incineration plant becomes operative.

Smaller communities will, for economic reasons, not be able to process communal refuse in the foreseeable future. Controlled Tipping may be suitable in these cases.

d) Most industrial refuse is not suitable for composting or incineration, and therefore has to be dumped unless it can be utilized by industry.

Both the capital required and the operating costs for Controlled Tipping depend largely on the site (transportation distance) and the work necessary for preparing it, which is determined by local conditions.

The costs include:

1. Capital
1.1 Acquisition of site (unless public property)
1.2 Sealing of site against groundwater
1.3 Acquisition of vehicles and equipment, fences
1.4 Construction of labor accommodation and equipment stores
1.5 Paving of access roads
1.6 Acquisition of additional garbage-transport vehicles if necessary because of long distances
2. Operating costs
2.1 Wages and social benefits
2.2 Depreciation
2.3 Materials
2.4 Work carried out by other bodies
2.5 Costs resulting from 1.6
2.6 Other costs

The investigations may yield the following results:

a) Dumps are available for all refuse for a considerable time. In this case the exact period has to be determined during which sites for Controlled Tipping are available (use of results of 0 – 3).

Controlled Tipping has to be included as of equal rank in the subsequent comparison of variants.

Detailed costing has to be carried out at maximum precision.

b) Sites for dumping are either not available at all, or only for a short time.

It has to be determined what volumes of refuse may be deposited in a controlled manner and what the approximate costs are. The results are important for a later decision on processing or dumping of refuse during certain seasons and/or from certain areas, which is unsuitable for processing.

0-2. Investigation of Marketing Possibilities of Products

An assured market for the products (compost or heat and clinker) is decisive for selecting the process. The demand for compost and the resulting marketing possibilities have to be discussed with the bodies using it.

These bodies may be:

- farms,
- horticultural enterprises,
- authorities in charge of green spaces,
- forest managements,
- other bodies and institutions (cemeteries, authorities in charge of motorways, etc.).

However, the expected demand for compost cannot be deduced solely from the results of these discussions, since compost obtained from communal refuse is a still little known product which frequently encounters sales resistance. Instead, the demand corresponding to the requirements of the users after their prejudices have been overcome, should be determined.

Estimation of this future demand is only possible after the following factors have been investigated in detail by experts:

- degree and intensity of agricultural, horticultural, or forestry use [of land],
- type of agricultural, horticultural, and forestry use, preferred crops,
- types of land,
- special local conditions (e.g., necessity of replanting waste heaps),
- meteorological conditions.

These factors have to be investigated for that area surrounding the planned compost plant, in which the sale of compost is not rendered impossible or uneconomical by excessive transportation costs.

Incineration of garbage without utilization of the heat is excluded in the GDR for economic reasons.

The possibilities of utilizing the heat produced will largely determine whether incineration of garbage is possible at all, and which method (burning of garbage for additional heat supply in high-pressure steam generators - burning of garbage with generation of steam for heating - burning of garbage with generation of electrical energy on site) should be included in the comparison of variants.

At the same time it should be investigated whether a market for clinker exists (building construction).

These investigations may yield the following basic results:

a) All or part of the thermal energy, which can be produced from the available refuse, can be marketed; compost is unmarketable.

Composting of refuse is not feasible.

b) All or part of the compost, which can be produced from the available refuse, can be sold; there is no market for heat.

Incineration of garbage is not feasible.

c) All or part of both heat and compost, which can be produced from the available refuse, can be marketed.

Both incineration and composting should be included in the comparison of variants.

Possibilities of marketing clinker improve the profitability of refuse-incineration plants, and are thus important for comparison of the variants. However, they are not decisive in the present stage of the investigations.

0–3. Investigation of Refuse

A precondition for the utilization of refuse by means of incineration or composting is that it satisfies certain minimum requirements as regards combustibility or compostability. The respective data have to be determined by means of qualitative analyses.

Since mass and volume of the garbage have to be known for subsequent planning, they should be determined in conjunction with the qualitative analyses.

Investigation of refuse should comprise:

1. Determination of mass and volume of garbage
2. Qualitative analyses
2.1 Qualitative analyses required for determination of compostability:
    - Moisture content
    - Content of organic matter
    - C/N ratio
    - Content of nonrotting matter
2.2 Investigation of calorific value
3. Investigation of other communal refuse (determination of mass and volume, qualitative analyses or estimates – type and extent of investigations depend on quantity and kind of refuse)
4. Estimation of future developments of the magnitudes determined under 1., 2., and 3

The following estimations have to be performed for this purpose:

4.1 Population increase, changes in population structure
4.2 Development plans for towns (reconstruction of town centers, new neighborhoods, demolitions, etc.)
4.3 Plans for locating and developing industry
4.4 Plans for establishing local services
4.5 Change in methods of heating and in fuel requirements of dwellings, institutions, and plants
4.6 Changes in food supply (packaging materials, kitchen refuse)
4.7 Other influences caused by changes in habits or standard of living.

Evaluation of the results of the analyses may lead to the following conclusions:

a) All the refuse collected throughout the year can be composted.
b) Part of the refuse can be composted (depending on the season and/or collection area)
c) The refuse is unsuitable for composting
d) All the refuse collected throughout the year can be burnt
e) Part of the refuse can be burnt (depending on the season and/or collection area)
f) The refuse is unsuitable for incineration.

3–4. Determination of Possible Processes

The results of investigations 0–1, 0–2, and 0–3 have to be compiled.

This will indicate which possibilities of refuse disposal have to be considered in principle, and which cannot be realized because of the negative results of the investigations already carried out, and therefore have to be eliminated.

4–5. First Estimation of Possible Site, Form of Organization and Collection Area

Selection of the optimum site for a refuse-disposal plant is an essential precondition for maximum cost effectiveness of the investment. Transportation costs, in particular, affect the costs of garbage disposal.

Those parts of the costs which depend on the site may be taken into account if preliminary investigations of sites are begun simultaneously with the comparison of the variants, and if their results are available early enough to be included in this comparison.

When the results of 0–3 (suitability of refuse for composting or incineration) are being evaluated, the collection area has to be considered or the different variants have to be roughly delimited in dependence on the processing capacities of the plants. Here it should be borne in mind that changes in the collection areas may under certain conditions have to be introduced in dependence on the season (e.g., if garbage collected in winter from areas where heating is by stoves cannot be composted because of the high ash content).

4–6. Determination of Plant Capacities in Dependence on Collection Areas

Mass and volume of communal refuse, which might be utilized by one of the possible processes (cf. 3–4), are given by the results of investigations 0–3. The quantities of the marketable products are also known (cf. 0–2). These represent the initial data for the following considerations:

High-capacity plants are generally more economical than low-capacity plants at equal degrees of utilization. On the other hand, the field of application of large plants is limited by the size of the collection and marketing areas: transportation costs increase with the distance over which garbage and additives have to be brought, and compost and residues or heat and clinker to be delivered.

The specific operating costs as functions of the plant size and the mean specific transportation costs as functions of the collection and marketing areas must therefore in each specific case determine a certain limiting quantity of refuse up to which a central plant is more economical, and beyond which decentralized plants are more economical. This limiting quantity need not be determined if the amount of refuse to be processed is less than the capacity of the smallest plant. Full utilization of the plant capacity should always be aimed at, since the fixed costs cause the specific costs to rise with decreasing degree of utilization. (It should obviously be considered whether a certain reserve capacity is not desirable in view of future extensions of the collection area and of increases in the amount of refuse to be collected).

The upper limit of the capacity of a given plant is determined by the technical possibilities. The number of shifts and the number of days per year on which the plant is in operation (limited, e.g., in the case of refuse-incineration plants, by the time required for boiler inspections; in the case of stack-composting plants, by down-time due to the weather) has to be taken into account.

The lower limit of utilization of a given plant depends on the maximum permissible specific costs, as has already been mentioned.

The plant capacity should therefore be determined according to the following considerations:

1. What is the total amount of refuse to be processed according to the methods found feasible in 3–4?

2. What quantities can be marketed over what distances (various radii drawn from a common center)?
3. Which types of plant and what sizes have a capacity approximating the values obtained under 1. and 2.?
4. It has then to be determined what capacity will involve minimum costs when a certain necessary reserve capacity is taken into account (variation of size and type of plant; changes in location and size of collection area; centralized or decentralized plants).

Determination of the capacity for the processes to be employed is a precondition for the technical-economic comparison of variants (cf. 7 – 8).

4–7. Technical-economic Assessment of Variants

For the comparison of variants see 7 – 8.

7–8. Completion of Technical-economic Comparison of Variants: Decision on the Variant to Be Chosen

Comparison of variants, begun in 4 – 7, has to be continued for those processes which have not been eliminated on the basis of preceding results, the data obtained in 4 – 5 now being taken into account.

The advantages and disadvantages of the various processes, which cannot be unambiguously determined quantitatively, have to be estimated according to the local conditions and compared in detail. This should be done for the site which is optimum for the process considered (cf. 4 – 5).

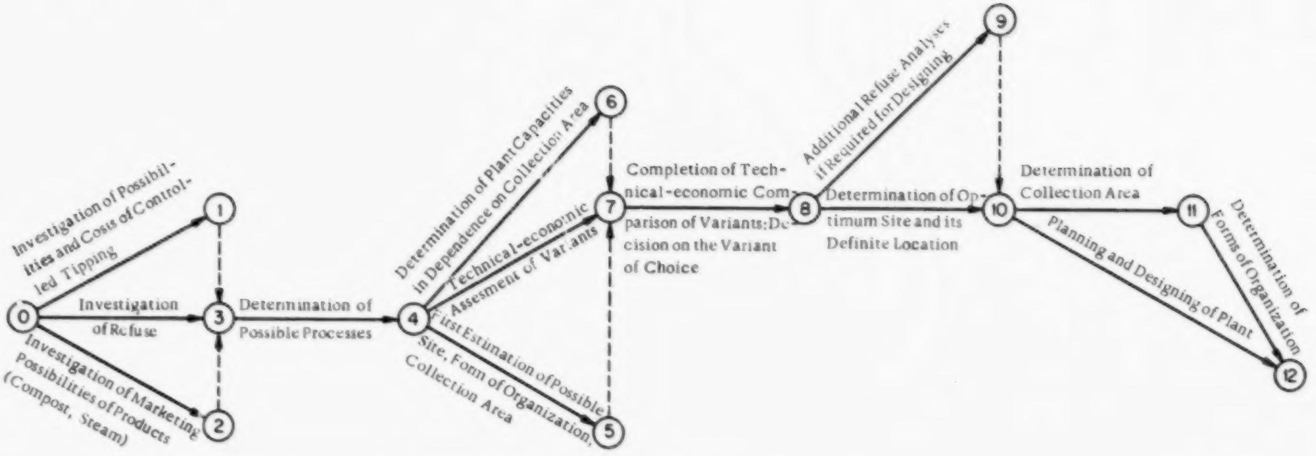
Determination of the costs of the various processes forms the principal part of the comparison of variants. The optimum site found in 4 – 5 is again used as basis. The costs have to be determined very carefully, since the economic aspects are the most important criterion in selecting the process.

The results of the investigations and calculations are compiled in a table. This includes all technical, technical-economic, and economic data on the various processes, which are important for assessing it and for making the final choice. The compilation should include at least the following data:

1. Plant capacity (quantity of communal refuse processed, quantities of compost or heat produced)
2. Investments (total, construction, equipment, subsequent investments)
3. Area required for plant
4. Labor required for plant
5. Total costs
6. Reductions in town or communal expenditure
7. Income from sale of products
8. Profit or loss
9. Rate of costs
10. Residues (percents by volume of initial quantity of refuse).

The process should be selected by considering all the data listed, including all consequences and influences which quantitatively cannot be determined unambiguously or at all. On no account should a single datum by itself be used as decisive criterion.

The results of comparison of the variants will decide which process should be selected.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Investigation of Possibilities and Costs of Controlled Tipping
Investigation of Refuse
Investigation of Marketing Possibilities of Products (Compost, Steam)
Determination of Possible Processes
Determination of Plant Capacities in Dependence on Collection Area
Technical-economic Assesment of Variants
First Estimation of Possible Site, Form of Organization, Collection Area
Completion of Technical-economic Comparison of Variants; Decision on the Variant of Choice
Additional Refuse Analyses if Required for Designing
Determination of Optimum Site and its Definite Location
Determination of Collection Area
Planning and Designing of Plant
Determination of Forms of Organization

Sequence of work for preparing the construction of plants for the disposal or processing of refuse

8–9. Additional Refuse Analyses if Required for Designing

The results obtained in 0–3 will generally suffice as basis for planning and designing refuse-processing plants. Should more accurate or additional data be required (e.g., precise calorific values for the design of garbage-incineration plants, or additional data from analyses for collection areas not initially taken into account), the investigation is performed as in 0–3

8–10. Determination of Optimum Site and its Definite Location

The importance of selecting the optimum site was mentioned under 4–5. The most suitable location can be fixed definitely after the utilization process has been decided upon.

10–11. Determination of Collection Area

The collection area can be finally delimited after the process and the plant site have been selected. No additional investigations are necessary for this, since the collection area has already been determined from the preceding work.

It will usually be necessary to replan the garbage-collection schedules.

10–12. Planning and Designing of Plant

The investment laws of the GDR require that this be done in three stages:

- Setting the technical-economic aim,
- Formulation of problem,
- Design.

CONCLUDING REMARKS

This schedule is an attempt to represent, according to their sequence, all investigations, planning work, and preparations necessary before construction of plants for processing or disposal of communal refuse is begun.

Detailed instructions have been or are being prepared for certain stages of the work.

The schedule should not be considered as a rigid and unchangeable scheme. Refinements and alterations will be introduced if they become necessary, or when new knowledge becomes available.

WHAT IS THE CAPACITY OF A GARBAGE-PROCESSING PLANT?[*]

By Dipl. Ing. Karl Wuhrmann, EAWAG, Zurich

Data on the annual costs of existing garbage-processing plants are increasingly becoming available. This not only facilitates taking decisions on how to plan garbage disposal, but introduces greater clarity in this field which until now has mainly been dominated by marketing interests and various predilections. However, all these reports should satisfy one condition, which unfortunately does not appear to be obvious: an exact knowledge of the

rated capacity,
the output, i.e., degree of utilization,
type of material processed,
required operating time,
emission,
ancillary costs,

for the plant considered.

Whereas there is general agreement on the methods [1,2]) of costing, evaluation of the results is often faulty, due to the lack of reliable information on the above-mentioned operating conditions. A person not familiar with problems of garbage disposal is often misled by general statements like "we process the garbage of our town of 50,000 inhabitants at a cost of DM 100,000 per year." He then assumes that the specific operating costs of garbage disposal are DM 2.- per inhabitant and year.

However, in fact only 5,000 tons might be processed per year, while 10,000 additional tons per year are dumped, being designated as "bulky matter, industrial refuse, fines, sieving residues, etc." Care should always be taken when not all the intake is weighed.

The most reliable results are obtained when all operating data are recorded continuously and published at the end of the year. Examples of this have recently become known in various countries. The specific costs in these cases are mostly higher than those given in reports containing incomplete operating data.

However, sometimes it is important, especially to the prospective owner of a garbage-processing plant, to have data on the costs as early as possible. A handing-over trial may then at least provide the technical preconditions for subsequent costing.

Principles regarding the minimum requirements to be satisfied at handing-over trials have been evolved in most branches of engineering; this, however, does not appear to apply to garbage-processing plants. Nobody would accept a new boiler unless at least the exact quantity of the fuel burnt and its composition were determined during the trial. However, these measurements are often omitted when garbage-processing plants are handed over. The reason for this is apparently that few independent organizations are able and willing to arrange and supervise a complete handing-over trial. Frequently an inspecting authority is consulted which evaluates only certain data, e.g., the emission from a furnace or the capacity of a hammer mill, without reference to the other operating magnitudes. Collaboration between two Swiss Federal Authorities (The Federal Materials-testing Institute (EMPA) for emissions into air and the Federal Institute for Water Supply, Sewage Purification, and Water Pollution Control for emissions into water and for the material taken in) has in Switzerland created the preconditions for complete handing-over trials comprising all operating conditions. Six towns and communities have already made use of these possibilites. Five garbage-incineration plants and one oil-sludge incineration plant were tested. In addition, a test intended to clarify certain operating problems was carried out in a compost plant.

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[*] See "Aufbereitungs-Technik," No. 5, Wiesbaden 1967.

A proper handing-over trial requires certain planning. This is usually based on the delivery contract for a plant and its guarantee and handing-over conditions. The test possibilities have then to be studied and the required experts and equipment to be provided.

1. Material

Weighing of solid matter is essential for determining the throughput. If a weighing bridge is provided in the plant, the hopper must either be emptied or subdivided in such a way that weighed-in material can be processed after a predetermined instant. It is important in advance to estimate the quantities to be processed during the handing-over trial since the hopper should be empty at the end of the trial if laborious and time-consuming reweighing is to be avoided. Measurement with the aid of tanks is possible in the case of sewage sludge and other liquids. For this, the level of the liquid in a cylindrical storage tank of suitable size is measured at the beginning and end of each refilling. Refilling and discharge durations should be determined with a stop watch, since the total throughput Q is given by the following formula when the discharge from the measuring tank is constant:

$$Q = \frac{F \cdot \Sigma \Delta h}{\frac{\Sigma tf}{1 - Te}}$$

Here F is the cross-sectional area of the tank, Δh are the increases in level during filling, tf are the filling durations, and Te is the discharge duration.

Flow meters are more suitable for clean liquids like drinking water or fuel oil.

Several papers [3-6]) have been published on the qualitative determination of the material taken in. The most difficult problem is representative sampling of solid refuse. The formerly used method of picking, which is time-consuming and unaesthetic, and has to be limited to insignificant quantities in view of labor availability, should be replaced by processes employing stepwise mechanical comminution [7]). The following properties are determined, depending on the purpose of the trial:

moisture content
content of organic matter
loss on ignition
calorific value
decomposable organic matter [6])
resistant organic matter [6])
content of matter soluble in petroleum ether
grain size distribution
etc.

Determination of several properties facilitates checks of the separate measurements by comparison, e.g., content of organic matter with calorific value.

2 Products

Ash, clinker, compost, and screen residues should be weighed. The plant should, as far as possible, contain equal amounts of material at the beginning and at the end of the trial. Undetected deposits of combustion residues may cause wrong conclusions to be drawn from short trials. Depending on the operating system of the plant, the trial durations should be as long as possible, e.g., at least 6 hours per run.

Where clinker is removed by flotation, the final moisture content is important. Repeated determination of the moisture content indicates the effectiveness of the method employed for moisture removal. The weight of the clinker may also be related to the weight of the material taken in.

Qualitative assessment of the clinker is a problem in itself. On the other hand, no complete agreement has yet been reached on the practical significance of the quality of combustion, while, on the other hand, the role of garbage clinker as material for tipping is still a matter of argument[8,9]). It is best to measure unambiguously determinable magnitudes, i.e., the moisture content, possibly the loss on ignition and the content of soluble matter. Specific leaching by acids or bases at arbitrary concentrations and durations of treatment are of little practical value.

Effluents and air pollution have also to be investigated. Much has still to be done as regards determination of quantities and properties of effluents. Frequently these are not easily accessible and their composition varies within wide limits, depending on the weather, especially in compost plants. It very often happens that the sewage conditions are in no way exemplary where garbage disposal is carried out for the sake of water pollution control. Determination of the emission requires at least measuring the order of magnitude of the efflux, its pH value, and in critical cases, its temperature or biochemical oxygen requirement. An extreme case of this is the use of garbage disposers fitted in kitchens.

Another product, which is important for the evaluation of the process, is compost. Its external properties, like freedom from splinters, content of plastics, and crumb structure can be determined visually, possibly in conjunction with sieving tests. Certain difficulties are, however, encountered in determining one of the most important properties of compost, i.e., its ripeness. Short-time planting trials with specially selected types of plants have so far not yielded sufficiently reliable results, while trial durations exceeding a fortnight are extremely inconvenient for continuous product control.

Amongst the most valuable methods of analysis are those which yield information on the presence of organic matter combining with nutrients, unless the carbon/nitrogen ratio is reduced to below approximately 20 by means of artificial enrichment with nitrogen. This is, however, hardly feasible from the aspect of communal economics. Laboratory methods have therefore been developed which permit determination of the contents of decomposable organic matter (DOM) and resistant organic matter (ROM) in the compost. However, these methods are rather laborious; work is being done at present to find simpler criteria[10,11]). Thorough ripeness tests are advisable in particular where so-called rapid composting processes are being employed.

Difficulties are also encountered in determining the quantities produced during composting, since the weight of marketable compost varies considerably not only with the season, but also with the moisture content which depends on several factors. A balance of all substances passing through the plant should be struck in order to obtain reliable data.

Determination of gaseous and air-polluting substances is possible by employing the methods of modern air hygiene. The emission of solid particles is usually measured in mg/m^3 STP. The CO_2 content is taken as reference magnitude in the case of combustion processes; this permits detection of ineffective dilution methods. It is easier in principle to determine the quantity of solid matter emitted, in percents of the quantity taken in. The problem is then sometimes raised whether solid matter condensed from the emitted gas or dissolved in droplets carried along with it, should be included in the count. Sulfur dioxide, which generally is important in air hygiene, mostly plays a subordinate role in garbage processing.

The situation is, however, different with respect to smells. Objective methods of determining these have so far not been developed, since even infinitesimal traces of smelling substances may cause offense, which in its turn can only be defined subjectively. Little that is definite can therefore be deduced in this respect from the handing-over trial. Nevertheless, smell is an important criterion of garbage disposal. Air hygiene in general is an important cost factor. Improper comparisons are possible if costing is carried out without taking these factors into account.

Determination of the quantities of steam or electric power supplied causes no difficulties where refuse-incineration plants produce energy. It is then important to determine what part of the energy is consumed by the plant and how much is delivered to outside consumers under competitive conditions, since this determines the actual efficiency of a process, irrespective of tariffs or other considerations.

3. Procedure

Successful realization of a plan for garbage-disposal plant depends on a clear formulation of the problem and of the requirements to be satisfied. The owner must be aware of the guarantees to be provided at the very latest when the contract is being signed; he must receive a binding promise by the supplier that they will be met.

These guarantees form the basis of the handing-over trial. If such a trial is envisaged already when the plant is being designed, the required measuring points can be provided at little extra cost, e.g., for determining the quantities of smoke or other gases emitted, whereas subsequent installation will sometimes entail costs for scaffolding, etc.

The different tasks have to be allocated when the program for the handing-over trial is being determined. The general contractor or the supplier of the principal processing equipment will usually operate the plant with his own staff during the handing-over trial, being aided by employees of the owner. The staff of the trustee should, independently of the operation of the plant, only carry out the measurements, note all events occurring during operations, and record and evaluate the latter; in particular, they should take samples on their own initiative. Three or four men will suffice to determine the quantities of matter taken in and discharged, exclusive of waste gases; measurement of emission into air may require the same amount of equipment or even more. One or two men have to be provided if significant sewage problems arise.

The results of the handing-over trial or trials should be given in detail in the report, at least as regards the principal data. The measuring accuracy should be indicated quantitatively by giving either the individual results and the weighted mean, or at least the latter and the range of scatter. In the latter case it should be investigated how far the scatter is due to the plant design and how far it is caused by the method of measuring.

The results may be verified by means of measurements. Mostly, however, only the overall balance for, e.g., solid matter, water, air, energy, etc., will permit reliable conclusions to be drawn. Comparison with the guarantee condition will determine whether the handing-over trial has been successful.

It may be concluded from the above that much work and knowledge is required in order to obtain those data on a garbage-processing plant which indicate its effectiveness and efficiency in a manner permitting comparison. The public interest demands that communities and organizations undertake these efforts, not only in order to know their own affairs, but also in order to provide design data for others.

Bibliography

1. Kupchik, G. Economies of Composting Municipal Refuse in Europe and Israel. – American Public Health Assoc., New York. 1965.
2. Wuhrmann, K. Die Jahreskosten der Abfallbeseitigung (Yearly Costs of Refuse Disposal). – Aufbereitungs-Technik, Issue 10. 1964.
3. Wiley, J and J. Spillane. Methods for Examination of Raw and Composted Organic Wastes. – U.S. Public Health Service. 1956.
4. Tanner, R. and R. Bopp. Die Technik der Müllverbrennung (Technology of Garbage Incineration). – Pro Aqua. 1965.
5. Haefeli, R. Durchfuhrung der Mullanalyse (Performing Garbage Analyses). – IAM-Informationsblatt No. 15.
6. Rollé, G. Probleme der Analyse von Mull, Kompost und Klarschlamm (Problems of the Analysis of Garbage, Compost and Sewage Sludge). – IAM-Informationsblatt No. 20
7. Rollé, G. Fahrbare Hammermuhle zur Aufbereitung von Müllproben (Mobile Hammer Mill for Preparing Garbage Samples). – IAM-Informationsblatt No. 22.
8. Wolfskehl, O and E. Boye. Einwirkung abgelagerter Mullasche und Mullkompostes auf das Grundwasser (Effects of Deposited Garbage Ash and Garbage Compost on Groundwater). – Schweiz, Bauzeitung, Issue 3. 1966.
9. Braun, R. Zur Frage der Beeinflussung des Grundwassers durch Ablagerungen von Verbrennungsruckstanden und Mullkompost (On the Effects on Groundwater of Deposition of Combustion Residues and Garbage Compost). – Schweiz. Bauzeitung, Issue 36. 1966.
10. Tepe, W., E. Leidenfrost, and A. Darlowsky. Einsatz von Schnellmethoden an Mull-Klarschlammkomposten zur Ueberprufung des Rotteverlaufes (Use of Rapid Methods for Testing the Rotting of Compost Produced from Garbage and Sewage Sludge). – IAM-Informationsblatt No. 28.
11. Obrist, W. Enzym-Aktivitat und Stoffabbau im rottenden Mull (Enzyme Activity and Decomposition of Matter in Rotting Garbage). – IAM-Informationsblatt No. 24.

OCCURRENCE AND DESTRUCTION OF OILY WASTE[*]

By R. Bopp, Dipl. Ing. ETH, Zurich

1. The Necessity of Hygiene

There is no need to explain the importance of our efforts to keep our living space clean. The reader knows from the daily press and from his own experience that the higher living standard is accompanied by an enormous rise in consumption of expendable consumer goods, leading to a proper waste of packaging materials. The rise in the living standard also causes a huge increase in motorization; this is clearly proved by the congested roads in the cities during the week and in the countryside on Sundays. According to the Mineral-Oil-Association 1,364,877 t engine fuel (gasoline, Diesel fuel, kerosene) and 58,787 t lubricants were imported into Switzerland in 1960. The internal consumption (imports and crude-oil products refined in Switzerland) of fuel was 2,275,873 t in 1965, that of lubricants 72,423 t. The increase over five years thus was 2/3 for fuels and 1/4 for lubricants.

The burnt fuel is emitted into the atmosphere as waste gas and contributes to air pollution. Only a small part of the lubricants is burnt; they reappear as used oil and greasy sludge when the oil is changed or the vehicle cleaned. We shall here consider the problem of what should be done with the used oil, termed "oily waste" in general.

A further consequence of the rising standard of living is the extensive use of oil heating installation for increasing the comfort. Instead of hauling coal or coke and servicing his stove as in former days, modern man sets the timing device and the thermostat and enjoys an agreeable climate without effort and attention, thanks to the automatically controlled oil heating. Import and/or consumed furnace oil amounted to 2,355,688 t in 1960 and 5,178,729 t in 1965. Consumption thus has more than doubled within five years.

We should enjoy this release from drudgery, but must not overlook the dangers incurred. Clean air and water, and hygienic disposal of refuse are necessary preconditions for a real and enduring enjoyment of the fruits of a prosperous economy and modern technology.

A short glance into the past shows that the necessity of water pollution control was recognized already a long time ago. According to the [Swiss] Federal Office for Water Pollution Control, on 1 Jan. 1966 there were 156 sewage-purification plants in operation, 56 under construction, and 77 ready for construction in Switzerland. The importance of air hygiene as part of work hygiene (silicosis) was recognized after the first World War. However, efforts to combat imminent danger to well-being have only been made for the last 20 years. Development of modern plants for the hygienic disposal of solid refuse has only been undertaken by the present generation; composting plants have been known for 10 to 15 years, incineration plants for about 30 years.

2. Technical Preconditions

The composition of household and industrial refuse varies greatly: waste paper, throw-away packaging, vegetable waste, boxes, radio sets, nails, wire, food cans, foliage, garden refuse, factory rejects, furnace residues, mattresses, tires, bottles,

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[*] See "Schweizerische Bauzeitung," Vol. 85, No. 9, 1967, Zurich

This explains why the requirements to be met by a refuse-incineration plant must be so high if faultless and orderly operation is to be ensured. Experience extending over decades has enabled Messrs. Von Roll AG., Zurich, to design and construct such plants which also meet all requirements as regards freedom from noise, dust, and smell: dust is removed from the combustion gases before they leave the stack. The clinker remaining after combustion is sterile and can be tipped without danger. The plant may be erected in a built-up area, so that the heat produced by the combustion can be utilized as steam or hot water at minimum costs. Due to the present unfavorable situation of public finances it is most important that refuse-incineration plants be designed correctly in every respect, so that they may be put into service without fail at the predetermined date and without exceeding the budgeted costs. Each design is "made to measure," being based on careful investigation of the quantities and composition of the refuse to be destroyed.

This awareness of a demand has during recent years stimulated studies of the destruction of oily waste. Formerly it could sometimes be observed how oil was changed in a car in the open field and allowed to penetrate into the ground. More severe regulations and understanding shown by car owners have now put an end to this. Certain oils penetrating into groundwater can affect its taste even if they are diluted at the ratio of $1:10^6$. It was formerly assumed that there was no need to care about furnace oil tanks once they had been buried in the ground. Such tanks are nowadays cleaned and inspected periodically, after pollution of groundwater had been traced to oil leakage through corroded plates.

However, the authorities have the moral right to prohibit free disposal of oily waste only if they make it possible for owners of cars, garages, oil-heating installations, and tank-cleaning enterprises, as well as for industry and trade to get rid of such substances in a correct manner. This necessitates the provision of collecting points, preferably in conjunction with refuse-incineration plants, so that used oil can be destroyed together with solid refuse.

Dilute oil-water mixtures (1 to 2%) may be enriched in different ways, e.g., by means of cold decantation in settling tanks. Mixtures with higher oil contents are introduced into the used-oil decantation plant of a refuse-incineration plant, together with used oil, cutting oil, paint residues, toluol, thinner, and sludge from oil separators and furnace oil tank. Such plants are most suitable for burning oily waste. They are provided with additional equipment ensuring hygienic conditions of work and perfect freedom from danger for the operating personnel, while not affecting the incineration of solid refuse.

Figure 1 shows the used-oil decantation plant in the refuse-incineration plant of the City of Geneva. The operating principle of a decantation plant for hot used oil, suitable in particular for mixtures with higher oil contents, is illustrated in Figure 2.

Oily refuse is delivered in tankers or barrels and is discharged into filling funnel (1). The latter has a sieve which retains large impurities like rags, broken gaskets, pieces of metal, etc. Decantation of the used oil is carried out in two heatable decantation tanks (3) under the influence of gravity. The oil mixture, being the fraction of lowest specific weight, floats on the water. Sludge and tar fractions settle at the bottom. The clarified combustible liquid is aspirated by transfer pump (4) through a floating suction head and delivered to heatable service tank (5), whence it is delivered by burner pump (6) to preheater (7). A viscosity regulator controls the temperature, so that the viscosity of the fuel entering the used-oil combustion chamber is maintained constant. This regulator is essential for correct operation of the burner, since the oily waste varies in composition, comprising all types of hydrocarbons between volatile solvents from printing shops and heavy engine oils.

If volatile solvents and liquid refuse with a very low flash point are available in considerable quantities, they are introduced into a separate tank and delivered

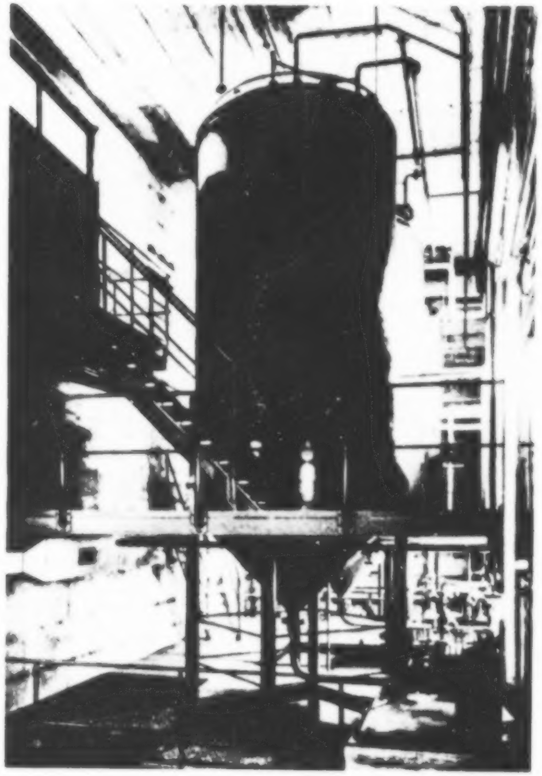


FIGURE 1. Used-oil decantation plant in refuse-incineration plant of the City of Geneva

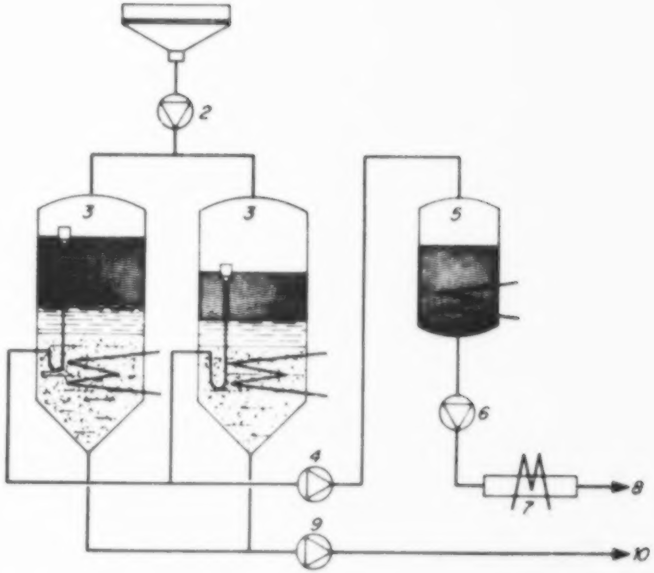


FIGURE 2. Operation principle of used-oil decantation plant
1. Filling funnel with sieve, 2. filling pump, 3. decantation tank, 4. transfer pump, 5. service tank, 6. burner pump, 7. preheater, 8. to used-oil burner, 9. sludge pump, 10. to refuse hopper

to the combustion chamber with the aid of compressed inert gas. Sludge and water are delivered by pump (9) through a heated pipe into the refuse hopper, in order to be burnt together with the refuse or to evaporate.

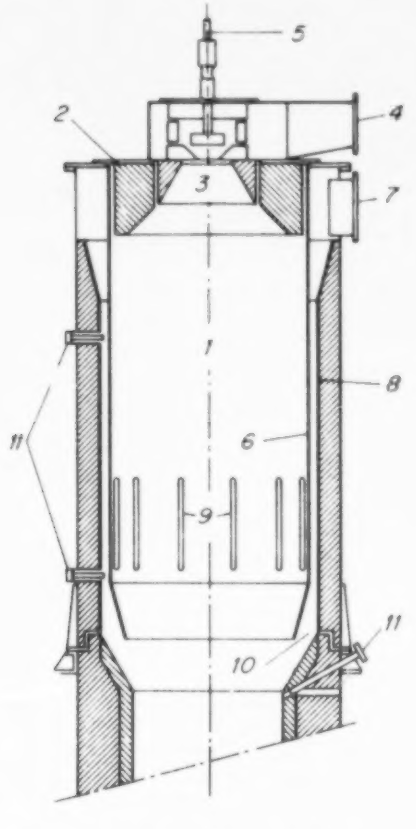


FIGURE 3. Longitudinal section through used-oil combustion chamber, type Von Roll. 1. Combustion chamber, 2. cover, 3. pulverizing device, 4. pipe-connection for primary air, 5. used-oil supply, 6. flame tube, 7. pipe connection for secondary air, 8. mantle tube, 9. slots for secondary air, 10. annular slot, 11. temperature sensor

The used-oil combustion chamber, whose longitudinal section is shown in Figure 3, is a patented invention of Messrs. Von Roll AG, Zurich. It consists of a vertical cylindrical chamber (1), open at the bottom, whose cover (2) contains fuel-pulverizing device (3). Combustion (primary) air flows through pipe connection (4) toward the pulverizing device. The combustion chamber consists of inner flame tube (6) and insulated mantle tube (8). Secondary air for cooling the waste gas is introduced into the lower part of the combustion chamber through slots (9) in the flame tube and through annular slot (10). This causes the gases produced by combustion of the oil to have the same temperature as the gases produced by combustion of the garbage. Both gas flows may therefore be mixed without the flying ash contained in the garbage waste gases fusing, adhering to the boiler heating surfaces, and fouling these.

Both air flows are created by two blowers arranged on a common shaft, and may be regulated independently according to the quantity of fuel delivered and the desired waste-gas temperature. Ingnition and control instruments for the combustion chamber are centralized in a control cabinet.

Figure 4 is a longitudinal section through a refuse-incineration plant. Used-oil combustion chamber (4) is arranged in the boiler house directly above predrying grate (5).

Figure 5 shows the combustion chamber of a refuse incinerator, viewed from the predrying grate in a direction obliquely upward. Part of the tubes of the radiant-heat exchanger and the passages admitting the gases to the second flue can also be seen.

The upper part of the picture shows the used-oil combustion chamber from below.

It is possible to operate the refuse-incineration plant without the used-oil burner. This is frequently done in existing plants. On the other hand, the oil burner may be used alone, only a layer of refuse slag being left on the grates.

Lastly, both furnaces may be operated simultaneously.

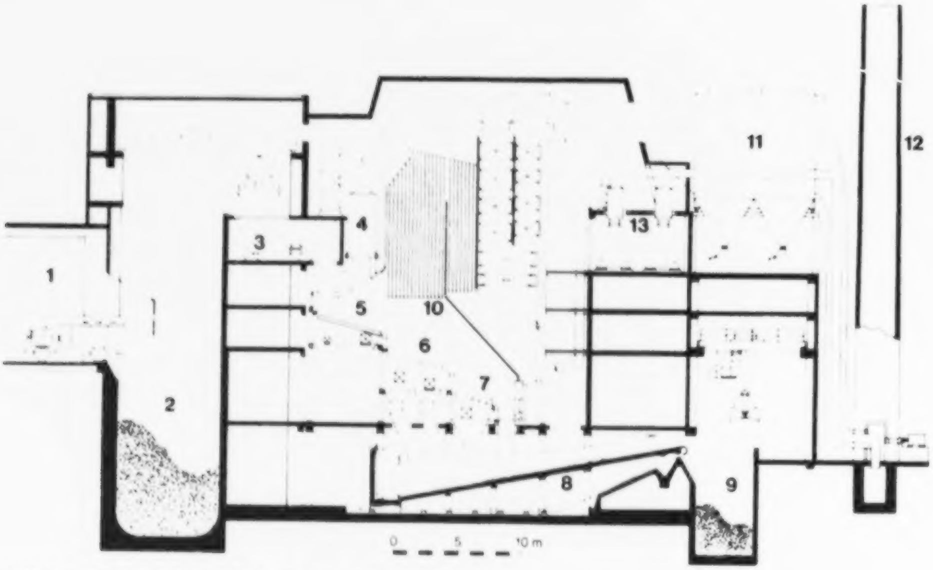


FIGURE 4. Longitudinal section through refuse-incineration plant
1. Discharge hall, 2. refuse hopper, 3. vibrator, 4. used-oil combustion chamber, 5. predrying grate, 6. main grate with scrapers, 7. final-combustion grate with scrapers, 8. clinker, 9. clinker hopper, 10. boiler, 11. electrostatic precipitator, 12. stack, 13. feed-water tank with deaerator

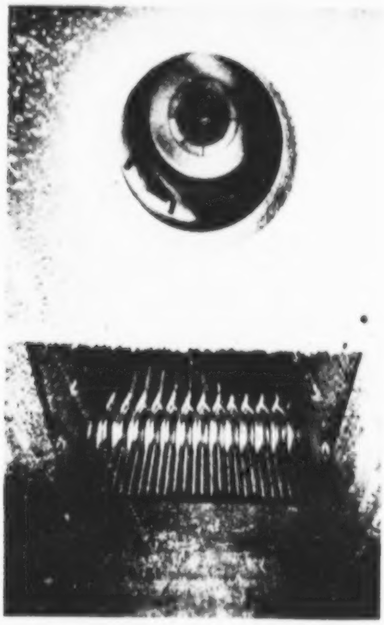


FIGURE 5. Internal view of combustion chamber of refuse incinerator

3. Design Data

In each specific case the designer faces the problem of determining the amount of used oil available in order to fix the size of the decantation installation and the capacity of the burner. Whereas the yearly quantity of solid household garbage per person is sufficiently known from data on existing plants and from the literature, this unfortunately does not apply to oily waste. Household garbage is mainly collected from garbage pails whose number is easy to determine. Solid refuse from trade and industry is mostly delivered to the plant by vehicles owned by the firms, and is weighed separately.

The situation is different with respect to the producers of oily waste. Individual households hardly supply any significant quantities of used oil. On the other hand, industry, garages, and tank-cleaning enterprises supply considerable quantities of used oil. The quantities delivered by industry can hardly be predicted. Those to be expected from all garages in a certain region should be correlated with a magnitude which can easily be determined statistically, e.g., the number of inhabitants. It should,however, be borne in mind that the extent of motorization is not the same everywhere (there are 314 vehicles per 1,000 persons in Geneva, but only 134 in Glarus). Hence, where it can be determined, the number of registered motor vehicles is used to predict the quantities of used oil supplied.

The amount of sludge from furnace-oil tanks, which may be delivered from tank-cleaning enterprises, can only with difficulty be estimated in advance, since the quantity of oil passing through the tanks, which is responsible for the sludge, depends on the climatic and economic conditions in the town considered. Although departments of statistics may supply data on the total number of buildings, it is almost impossible to determine the number of buildings provided with oil heating.

An inquiry, recently carried out by Messrs. Von Roll AG, Zurich, has proved how difficult it is to obtain information from towns on the quantities of used oil available in their areas. A considerable number of towns received questionnaires in which the following information was requested:

> Number of inhabitants, number of registered motor vehicles, total number of buildings and number of those provided with oil heating; solid household refuse (t/year), solid refuse from trade and industry (t/year), oily waste from households, trade, and industry (t/year); composition of oily waste (gasoline, benzene, solvents; oils; sludge and tar residues; water).

Approximately 20% of the circularized towns returned the questionnaires. The data thus obtained were supplemented, as far as necessary, by those published by K. Wuhrmann[1]) and based on experience. Wuhrmann found that 5.5 kg used oil were obtained per vehicle (including trucks) and year, as well as 1 kg sludge from furnace oil tanks per inhabitant and year or 10 kg per building and year. (Wuhrmann's data do not take industrial oily waste into account).

An attempt was made in Table 1 to obtain weighted means from the available data. The sum of all oily waste is subdivided according to three principal groups of producers, and the respective quantity per inhabitant is calculated. Wuhrmann's data, i.e., 5.5 kg used oil per motor vehicle and year, have been used in the Table. The other data were obtained from the results of the inquiry mentioned and from estimates of oil-heating installations. The difference between the total amount of used oil and the sum of the quantities obtained from motor vehicles and furnace-oil tanks represents the quantity of used oil supplied by industry. This yields a mean value for regions with an average development of trade and industry.

Used oil is ordinarily burnt in the same plant as solid refuse. The respective parts of the plant therefore must be coordinated. The last line in the table shows

TABLE I Oily waste and solid refuse of model town per year

Number of inhabitants		400,000
Number of motor vehicles		100,000
Used oil from motor vehicles	t	550
	kg/inhabitant	1.4
Number of buildings		40,000
of these with oil heating		40%
Sludge from furnace-oil tanks (heating of buildings)	t	250
	kg/inhabitant	0.6
	kg/building	6.3
Oily waste from industry	t	400
	kg/inhabitant	1.0
Total oily waste	t	1,200
	kg/inhabitant	3
Solid garbage	t	84,000
	kg/inhabitant	210
Ratio of oily waste to garbage	kg/t	14.3

the weight of the two kinds of refuse. Oily waste represents approximately 1.5% of the weight of the garbage, thus yielding about 7 to 10% of the heat produced, if the calorific values are taken into account.

Due to the scarcity of data the statistical corroboration of these results is not very good. Deviations of ± 25% are quite possible in certain cases. It would be appreciated if other towns, spurred on by this paper, would ask for questionnaires and return them filled in to Messrs. Von Roll AG, Zurich. More detailed and generally applicable design data could then be published in a further paper.

DISCUSSION

Dipl. Landwirt Otto Andres, President of the Farmers and Wine-Growers Organization of Rheinland-Nassau, Bad Kreuznach, who has much practical experience in composting of garbage and in the use of compost in agriculture, has been so kind as to comment on the problem of "Composting within the Framework of the Overall Refuse Problem" from the viewpoint of the German Federal Republic:

The aim should be disposal of all refuse, causing as little damage as possible. This may be achieved by means of controlled tipping, composting, and incineration. The refuse problem can usually be completely solved only by combining two or all three of these methods. This can only be done if all local conditions are investigated without preconceived ideas, and the results then used for planning, while outside influences are excluded. It has unfortunately become normal nowadays to demand general solutions which should be applicable to every case. I consider these to be very harmful in such a variegated field as refuse disposal. In fact, they form an obstacle to effective solutions. Even the fundamental division into principal and ancillary processes is wrong, being an unrealistic schematization. Planning of refuse-disposal plants is a subject not for theorizing dogmatists but for well-informed, intellectually mobile, imaginative, practical, and creative people.

Even composting can only solve the refuse-disposal problem partially, i.e., for household garbage, drained sewage sludge, and certain organic industrial refuse. However, in the German Federal Republic there still are many areas with a low population density and without any industry worth mentioning, in which household garbage and sewage sludge are almost the only refuse; this applies to many subdistricts in the hilly regions. Besides the hilly regions of my own home country I am referring to a case in Upper Bavaria: 185,000 inhabitants (including tourists) dispersed over an area of about 3,000 km², two thirds living in villages of 100 to 1,000 inhabitants; investigations have shown that there is hardly any combustible industrial refuse available in this area. In such regions it is usual to homogenize and tip the refuse (including bulky garbage) without costly installations or large expense. This only requires fixed or mobile comminution plants and the necessary vehicles. In many cases this will suffice for the next 10 to 15 years. We should free ourselves from the perfectionist idea that composting is necessary in such areas. No demand for humus exists there, since a large part of the land is cultivated. The problem thus is to dispose of the refuse in the most economical way.

On the other hand, there are many regions in the German Federal Republic where the soil is poor or shallow (the extent of these areas is much larger than assumed by laymen in soil science), or where crops are grown which are particularly suitable for the use of compost. Mostly this soil also has poor water-retaining properties, is liable to erosion, and the groundwater has a high and still increasing nitrate content. This is of concern not only to agriculture but to all. From the viewpoint of national economy it would be negligent to burn all refuse instead of attempting to find suitable economical combinations of incineration and composting for large areas. This applies, e.g., to very large parts of the Rhine Valley between Bingen and Basle.

However, even at obvious locations for incineration plants, i.e. in cities, industrial conglomerations, etc., it might be useful to compost part of the refuse in order to meet the requirements of communities, for the maintenance of public green spaces, for covering slag and other tippings, etc. The reader is referred to Guldemann's paper in IAM Information Bulletin No.28. Netherlands sale statistics indicate a continuously increasing demand by these nonagricultural users. In 1965 it amounted to 41%, which represents more than $^2/_5$ of total sales.

Composting of refuse has not lost its importance. In the German Federal Republic it will steadily become more important with the increasing necessity for landscape protection. This is not only my opinion but also that of all those who desire a healthy landscape in the public interest. Disposal possibilities are limited for slag, but unlimited for compost. Incorporation into the landscape usually poses a problem for slag disposal, while the disposal of compost ordinarily is completely unproblematical.

We cannot and do not wish to eliminate burning of the large amount of industrial refuse and oily waste. However, can **everything** be burnt in **any** incineration plant? Thus, can all used tires obtained in a certain area be burnt in existing incineration plants? This obviously is not the case.

An inquiry concerning the disposal of oily waste carried out by the Federal Health Office at 24 incineration plants in service or under construction, yielded the following result: "The possibilities of burning used oil and oily waste in household-refuse incineration plants are limited."

It is known what difficulties are encountered in ordinary incineration plants when large amounts of plastics and certain other industrial refuse are delivered.

It is thus wrong to assume that an omnipotent incineration plant might provide a general solution, as if it might be possible to burn **all** refuse **economically** in a **single** incinerator, including refuse about which nothing is known at the time of planning, but which might become available within a short time. Would it not be more sensible to provide special incineration plants for certain refuse collected over large areas?

There will be no general solution for the disposal of sewage sludge. Instead, different ways will be employed, depending on the location of the plant. As known, the Niers organization has successfully deposited wet sludge. Good results have been obtained near Trier with the tipping of barely plastic sludge from drying basins at the upper edges of vineyards, from where it flows downward through the rows like viscous lava. We have successfully composted spadeable sewage sludge with garbage; valuable dried sewage sludge is available. Sludge may be burnt at high cost where no other disposal possibilities exist.

It is my opinion that, in analogy with deposition of compost on top of the soil, the deposition of wet sludge may be the cheapest manner of disposal for many communities. Thus, there are 185 km of rural roads within the area of Bad Kreuznach. A total area of 1,850,000 m^2 will thus be covered if the sludge is once a year dispersed along these roads over 5-m wide strips on both sides. If a 1-cm high layer of sludge or compost is thus deposited, this will dispose cheaply of 18,500 m^3 refuse residues. However, it should be possible to repeat this procedure several times per year, as well as to increase the throwing range and the layer thickness. I am certain that with some imagination many other possibilities will be found for disposing of compost and sludge. I also consider that composting processes can still be simplified in several respects, and that it will be possible to process more sewage sludge. What objections might there be against using the Van Maanen process in a large region?

Summarizing, I should say that:

Composting of refuse is advisable

1. where this is the most economical process (e.g., Pinneberg);
2. where soil amelioration is necessary for reasons of national economy, e.g., retention of water in dry areas, water hygiene in a general sense (nitrates), prevention of erosion due to washing or blowing away of the soil, making arable or restoring devastated land, provision of humus to public green spaces, supply of covering material for dumps, etc. (First example: original purpose of plant at Wijster, Netherlands; second example: Füllinsdorf, canton Basle-Land);
3. where agriculture is interested in paying for compost for its crops (e.g., Bad Kreuznach).

It is obvious that in cases 1 – 3 a different method of disposal (controlled tipping, own incinerator, or burning in some other plant) must be provided for refuse which cannot be composted.

We become impatient too quickly. Ten years ago, when we started with our composting plant, I imagined that we might at the first attempt win over farmers to this manner of soil amelioration. I found out very soon that mental inertia of human beings is a serious obstacle. It takes a long time until people become interested and convinced, and much opposition has to be overcome. However, constant efforts do yield results. Ten years ago our ideas were met with reserve or were rejected by scientists, teachers, consultants, and even practical farmers. Nowadays these ideas are increasingly being accepted by experts and agricultural organizations.

We always see the marketing successes in the Netherlands, and despair about those in our country. We forget too easily that the Netherlands are 20 to 30 years ahead of us. This period includes the Second World War with its scarcity of artificial fertilizers. It was then that compost from Wijster became a desired product throughout the Netherlands almost overnight and without any publicity. We mostly forget that two excellent organizations exist in the Netherlands: the "VAM" marketing organization and the consulting organization of the "Stichting Compost." Both are supported by all relevant authorities and organizations, from the various ministries to the agricultural college at Wageningen to the last technical school and the associations. Neither in Switzerland nor here has it yet been possible to organize anything similar. However, we should continue with our efforts.'

Contribution to Discussion

Dipl. Landwirt. A. v. Hirschheydt, Schwerzenbach (Switzerland)

Bulletin No. 28, December 1966, contains a critical review by Mr. Stahlschmidt of my paper published in Bulletin No. 26, of April 1966. It was to be expected that negative opinions would be expressed by builders of compost plants. It is significant that none have been voiced by consumers of compost (testing institutes, etc.).

Mr. Stahlschmidt's comments are not altogether unbiased. I am not replying to every single point of his arguments, not because it is impossible to refute them, but so as not to extend the discussion boundlessly. Thus, I shall reply only to the main points.

1. Users. So far as cultivation of fields and green land is concerned, Swiss agriculture relies mainly on its own resources for the supply of humus. Thus, organic fertilizer production is determined mainly by the ratio of cultivated fields to green land. Geering / 1 / states that purchase of refuse compost by Swiss farmers, in general, is not advisable for reasons of private economy. We need not consider exceptions to this.

The report of the "Stichting Compost" /2/ contains the following passage: "Town-refuse compost has little direct effect on the cultivation of heavy soils. The same is true for light-soil agricultural plots which are fertilized regularly with manure. Usually these plots form part of a mixed farm. Therefore, in both cases, which include most cultivated land in our country, town-refuse compost should not be used for reasons of private economy." On the other hand, "visible results are obtained on cultivated plots with sandy soil and meadows which are rarely fertilized with manure." The Productivity Rate is given as 10 t/ha/year.

This may also be applied to the German Federal Republic. Conditions which would justify the use of refuse compost are rarely encountered in Switzerland, if at all, certainly not to a significant extent. Perhaps Mr. Stahlschmidt is unaware of this.

2. Determination of areas. All references used are stated in my paper. This includes Swiss Federal sources and supplementary information by the relevant authorities. The term "estimates", therefore, should not be used in general. However, where no sources were available, the data had to be derived. This shortcoming is known to me and was mentioned. I shall always be grateful for more complete information. Criticism without suggestions for improvements is, however, of little use.

3. Requirements. In the case of PR, the problem is not the quantities used but the wastage of humus. These data cannot be applied to tree nurseries, where the loss of humus [removed with the trees] must be added to the wastage. Swiss experience with vineyards, mentioned by Mr. Stahlschmidt, which, if taken into account, might cause changes by several 1,000 t/yr, instead of 100 t/yr, refers to trials of preventing erosion, and has nothing to do with humus wastage.

According to my source 10 / 2 /, and using my method of computing the PR, the latter may be determined as 2,245 million t/yr for the cultivation of fruit, vegetables, flowers, and ornamental plants in the Netherlands. According to the same source, the sales to be expected (a Sales Rate in my meaning) are about

0.2 million t/ yr., i.e., 9%. My estimates for the same branches of farming in Switzerland, i.e., $+{}^{1}/_{3}$ as compared with the Netherlands (specifically), are quite bold. If Mr. Stahlschmidt believes that he might reasonably obtain higher values, it must be regretted that he has not given his derivation. Undoubtedly, this would have been of value for the discussion.

The yield obtained by using refuse compost (RC) depends largely on the type and condition of the soil. The better the soil is in this respect, the smaller the increase in yield to be expected. The source mentioned by Mr. Stahlschmidt (I also know it, but could hardly use it since it had not been published when my paper was printed) contains no information on the type of soil. The many sources used on sugarbeet cultivation with RC in the Netherlands, in most cases plainly refer to sandy soil. The type of soil was not mentioned in some cases, while only a few cases referred to loam. The results thus obtained cannot simply be applied to Switzerland where such soils mostly do not exist.

4. Satisfying requirements. It was mentioned how the RC supply was determined. It need not be considered here what its relationship is to production in the Netherlands. The assumption that 120 kg RC per inhabitant and year is excessive seems to be improbable also, according to newer data.

5. Graphical representation. As far as I know, there is no proven connection between the distance up to which transportation of RC is feasible from the viewpoint of private economy, and the capacity and size of the plant. Mr. Stahlschmidt's suggestion would make sense only if a considerably smaller area were able to use the production, i.e., if underproduction existed in relation to demand and requirements. This, however, is not the case.

Unfortunately, the term "horticultural quality" is not defined precisely. Splinter removal in Swiss composts usually is such that they may be, and are, used in horticulture, including pot gardening, without any difficulty. Otherwise, designers of compost plants would certainly have introduced improvements.

6. Conclusions. The claim made under this heading, that it might equally be found that not enough refuse compost can be produced in Switzerland during the next 20 years, has not yet been proved. Accumulation of unsold compost was to be avoided. Unfortunately this has not been possible everywhere.

Attentive readers will hardly confirm that my assumption, i.e., the existence of an ex-plant price, is "hidden in a postscript" (cf. Section 1 of my paper).

It is probable that cheaper material than RC produced at a cost of SF 30.- to 40.- per ton will be found for covering refuse tippings. Good examples of how this can be done well and more cheaply are available in Denmark.

In one respect Mr. Stahlschmidt commits a very serious error: it is not the duty of a government consulting office or its employees to build up a marketing organization for the overproduction of compost, caused by the eagerness of industry to sell. Interested firms might perhaps concern themselves with this matter. Examples of this are said to exist.

1. Geering, J. "On the Utility of Refuse to Agriculture, Determined from Results of Field and Pot Tests." Schweiz. Landw. Forschung 3/1964.
2. Stichting Compost: "de behoefte aan stadsvuilcompost in nederland" Wageningen 1960.

Editor's comment

Since the problem of decreasing compost sales to Netherlands agriculture has been raised in this discussion (see Bulletin No. 28), we quote, as requested by Ing. Stahlschmidt, the relevant passage in VAM Meddelingen, March 1966, 21st year, No. 1, p. 1.:

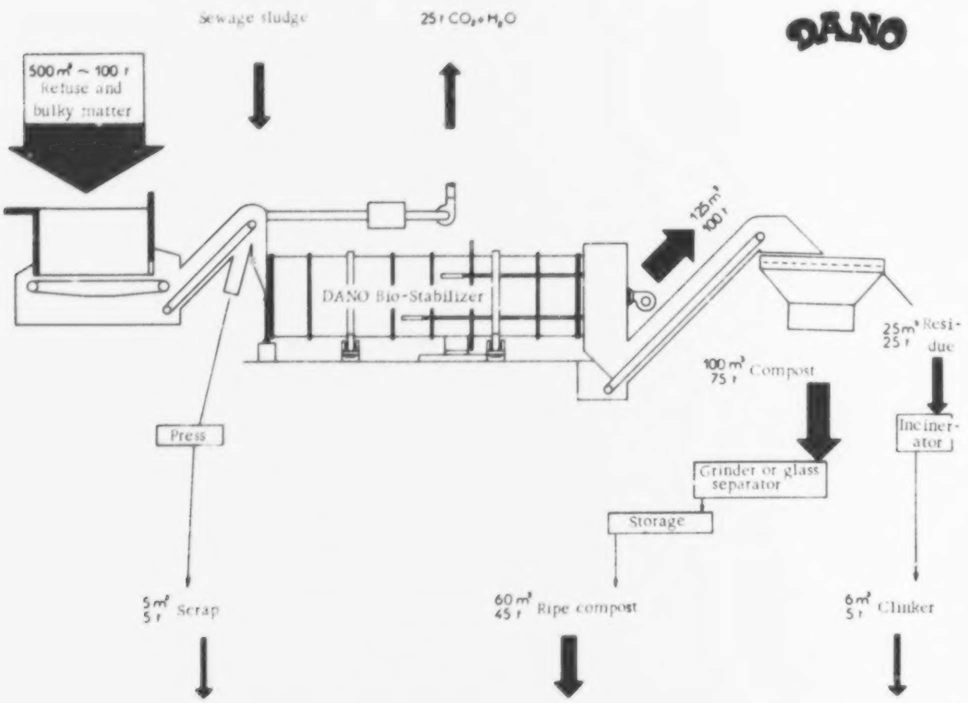
"compostgebruik in de landbouw: Het gebruik van compost in de landbouw is de laatste jaren teruggelopen. Dit is niet een gevolg van het feit dat de resultaten van compostbemesting minder goed zouden zijn dan vroeger. De werkelijke oorzaak is dat de vraag naar de duurdere compostkwaliteiten voor de tuinbouw en de recreatieve sector sterk is toegenommen, waardoor de compostbedrijven zich meer zijn gaan toeleggen op de productie van de duurdere kwaliteiten ten koste van de goedkopere landbouwkwaliteit, zodat er voor de landbouw minder overbleef. . ."

It would be desirable if colleagues from the Netherlands would comment on this problem.

COMMUNICATIONS FROM INDUSTRY

Development of the DANO Process. 1. Continuation

Development of the DANO-Bio-Stabilizer, based on self-grinding of the refuse and bulky matter, has been described in IAM Bulletin No. 29. The Bio-Stabilizer process owes its rapid propagation (more than 100 units have been put into service


Sewage sludge
25 t CO₂ + H₂O
DANO
500 m³ ~ 100 t
Refuse and
bulky matter
125 m³
100 t
DANO Bio-Stabilizer
25 m³ Resi-
25 t due
100 m³ Compost
75 t
Press
Incinerator
Grinder or glass separator
Storage
5 m³ Scrap
5 t
60 m³ Ripe compost
45 t
6 m³ Clinker
5 t

Schematic representation of Dano process with data on average values of biological degradation. Volume reduction is indicated by the width of the arrows representing passage of material which is proportional to the volume of the latter.

in ten years) to its simplicity. Grinding, volume reduction, mixing, pasteurization, hot fermentation, and drying take place simultaneously in a single stage. Particularly with such nonhomogeneous material, should unnecessary treatment or transportation be avoided.

The Dano-Bio-Stabilizer is charged by means of a Dano-plate conveyer which, in contrast to grabs, need not be manned, and delivers the material quickly and continuously. The Bio-Stabilizer separates only scrap. Pressed scrap is in great demand nowadays.

Microorganisms act continuously for 24 hours in the Bio-Stabilizer, assisted by continuous churning and intensive aeration. The time during which the refuse stays in the Dano-Stabilizer varies between 50 and 100 hours, since the Bio-Stabilizer is operated at optimum filling, being charged and emptied daily.

Final treatment consists only of sieving. The fineness of the sieve depends on the required quality of the compost. The process may be complemented, as required, by a glass separator or a fine grinder for final treatment of the compost, or by an incinerator for burning the sieving residues.

The DANO-Bio-Stabilizer in many respects is similar to a biological sludge basin for wastewater purification: organic matter is degraded and converted in it. The term "stabilizer" becomes justified if this analogy is borne in mind. Although much organic matter is degraded and stabilized, the final product is no more stable than secondary sludge of wastewater purification plants. Just as a more stable sludge results from long aeration in a purification plant, so a more stable compost is obtained when the refuse remains in the Bio-Stabilizer for a long time.

The "stability" of compost is difficult to define and determine. Investigations of entropy, growth and sprouting tests, Chaetomium tests according to Dr. Obrist, and chemical analyses are performed in order to provide, singly or jointly, information on the stability or ripeness of a compost. However, all these tests are very laborious; the search for new methods is very intensive. A method of determining the consumption of oxygen, similar to the BOD5 [Basic Oxygen Determination] is now being investigated.

The principal consumers of oxygen in refuse, i.e., fats, proteins, and fermentable carbohydrates, are largely degraded in the Bio-Stabilizer. Cellulose is only partially attacked and degraded; this takes place more slowly the more strongly the cellulose is imbedded in lignin. The content of cellulose and lignin in refuse and bulky matter nowadays is higher than before, so that decomposition of these substances is particularly important. During the last years the Dano Company, in collaboration with the Danish "Biocentralen" Research Institute, has investigated the theoretical and practical possibilities of rapid decomposition of cellulose.

These investigations resulted in the following process for obtaining ripe compost: refuse is held in windrows which are not too high, and is turned three times every third week, using a fully automatic turning device; each particle is aerated and moistened as required. DANO windrow-turning devices have been in use for years and much experience has been gained with them; the same is true for the marketing possibilities of ripe compost.

The demand for ripe compost has always exceeded the supply, although its price is three or four times as high as that of fresh compost.

How far complete ripeness is necessary is open to argument. Many experts on humus would prefer the ripening process to take place in the soil, although nitrogen and phosphorus in this case are fixed some time. Fixation of these nutrients may or may not be desirable, but has to be taken into account in every case. Ripe compost is undoubtedly preferred for many purposes.

A second continuation of this communication will deal with the experience gained with compost in horticulture and agriculture.

Further development of the basic Dano principle — self-grinding in horizontal rotating drums — has proceeded in the following directions during the last years:

Design of smaller, faster rotating drums so as to achieve a most economical reduction in refuse volume, as a first stage for controlled tipping.

Technical perfection of the Bio-Stabilizer as regards protection against wear, design of cutting members, and air flow. Improved air flow has made a maximum aerobic fermentation possible.

Improvements concerning evacuation and treatment of fermentation gases.

Development of processes and machines for producing ripe compost.

Studies of the uses of compost.

BOOK REVIEW

Wasser and Luft in der Raumplanung (Water and Air in Living-Space Planning).
Report on the Pro Aqua 1965 International Symposium in Basle. 1966. 424 pp.,
116 fig., DM 116.–, cloth bound. Pro Aqua AG, Basle.
Edited by Hansjorg Schmassmann, Verlag R. Oldenbourg, Munchen.

This complete edition of all papers read indicates the importance of problems of water and air hygiene in our era of extensive industrialization. The effects of hydroelectric plants on open water are considered by E. Marki and J. Killer. An acceptable compromise has to be found between the requirements of drinking water and water for energetic purposes. H. Krause explains the problems of clean-air purification in nuclear-power plants; the corresponding problems of clean-air maintenance are discussed by J. Pradel, and S. R. Craxford considers clean-air maintenance in thermal power plants.

In the field of "Planning of Water Supply for Drinking and Other Purposes" the importance of groundwater protection and collection zones is discussed by H. Schmassmann, E. Trueb, A. Casati, and E. Merkofer; water supply from rivers is considered by C. van Rooijen, and from lakes, by F. Schmidt. D. Davies discusses drinking-water storage basins, A. Burger, superregional supply systems, and W. Kumpf, measures for supplying water during emergencies.

The section on disposal of industrial refuse, which here is of particular interest, contains the following papers:

R. Braun : Regional Plants for the Disposal of Nondecaying Industrial Refuse.
H. Leib : Technical Requirements with Regard to Plants for the Disposal of Nondecaying Industrial Refuse.
E. Zehnder : Refuse Disposal in the Case of Breakdowns.
L. Hammer : Central Plants for the Detoxication of Liquid Concentrates.
H. P. Zwicky : New Possibilities for the Detoxication of Cyanide Concentrates according to the Berliner-White Process.
F. Oehme : Detoxication of Chromates in Alkaline Surroundings in Wastewater Mixed with Cyanide.
W. Luck : Electrical Cyanide Checks in Wastewater from Galvanizing Plants.
M. Rutishauser : Wastewater from Cellulose Plants and Possibilities of Its Purification.

Possibilities of satisfactory waste disposal are explained by these experts in clear and well-documented papers.

The book ends with discussions of technical problems of wastewater purification and treatment of bathing water. A good insight into the various aspects of the hygiene of the surroundings is thus given, showing how we can effectively protect the space we live in from noxious influences.

W. Obrist

LITERATURE RECEIVED BY THE SECRETARIAT

Albinus, G. Kritische Betrachtungen uber die Mullverbrennung in kleineren Anlagen (Critical Considerations of Refuse Incineration in Small Installations). – Müll-Abfall-Abwasser, Issue 5, Verl. A. Schweiger, 516 Duren. 1967.

Andersen, J. R. and J. N. **Dornbusch**. Influence of Sanitary Landfill on Groundwater Quality. – Journal American Water Works Association, Vol. 59, No. 4, New York. 1967.

Arnst, F. Fuhrpark- und Stadtreinigungsbetriebe auf neuen Wegen (New Approaches to Vehicle- and Town-Cleaning Management). – Stadtehygiene, 18th year, Issue 6. 1967.

Battelle-Institut, Frankfurt a/M. Untersuchung uber die Möglichkeiten und Kosten verschiedener Transportsysteme beim Ferntransport von Müll (Investigations of the Possibilities and Costs of Different Systems for Distant Transportation of Refuse. – Mull-Abfall-Abwasser, Issue 5, Verl. A. Schweiger, 516 Duren. 1967.

Bevan, R. E. Controlled Tipping of Refuse. The Institute of Public Cleansing, 28 Portland Place, London W. 1. 1967.

Bittmann, M. and K. **Seidel**. Entwässerung und Aufbereitung von Chemieschlamm mit Hilfe von Pflanzen (Dewatering and Processing of Chemical Sludge by Means of Plants). – Gas- und Wasserfach, Wasser/Abwasser, Issue 18. 1967.

Brugger, G. Die Aufbereitung von stadtischen Siedlungsabfallen und ihre Verwendung (Processing Town Refuse and Its Use). – Mull-Abfall-Abwasser, Issue 5, Verl. A. Schweiger, 516 Duren. 1967.

Burger, G. Der Schmelzkorpertest – eine einfache Methode zum Prüfen des Entseuchungseffektes der aeroben Kompostierung (The Fusible-Body-Test – a Simple Method of Determining the Disinfecting Effects of Aerobic Composting). – Zeitschr. f. d. gesamte Hygiene und ihre Grenzgebiete, Issue 7, 13th year. 1967.

Claus, H. Mullprobleme im Raume Neunkirch-Saar (Garbage Problems in the Area of Neunkirch-Saar). – Der Stadtetag, Issue 9. 1967.

Edelhoff, G.-D. Der private Stadtreinigungsunternehmer und seine Aufgaben (The Private Town-Cleaning Enterprise and Its Problems), – Städtehygiene, 18th year, Issue 6. 1967.

Einbrodt, H. J. and H. **Reploh**. Zusammensetzung und Eigenschaften des Strassenkehrichts einer Industrie-Grosstadt (Composition and Properties of Road Refuse in an Industrial City). – Stadtehygiene, 18th year, Issue 6. 1967.

Erhard, H. Grundsatzliches uber Mullabladeplatze (Fundamentals of Garbage Disposal Plots). – Stadtehygiene, 18th year, Issue 6. 1967.

Doose, U. INTAPUC – 9th International Congress in Paris. – Der Stadtetag, Issue 9. 1967.

Hauk, H. Die Müllbeseitigung in der Südpfalz (Refuse Disposal in the Southern Palatinate).—Der Städtetag, Issue 8. 1967.

Hiebach, Einenkel und Dahl. Neues Verfahren der mechanischen Mietenkompostierung (A New Process for Mechanical Windrow Composting).—Die ortliche Versorgungswirtschaft, 3rd year, Issue 4, Dresden. 1967.

Kutzschbauch, K. Zusammensetzung und strukturelle Entwicklung des Hausmulls von Gross-Berlin (Composition and Changes in the Structure of Household Garbage in Greater Berlin).—Zeitschrift für die gesamte Hygiene und ihre Grenzgebiete, 12th year, Issue 10. 1967.

Link, P. Die gefahrlose Beseitigung anorganischer Industrieschlämme (Harmless Disposal of Anorganic Industrial Sludge).—Das Gas- und Wasserfach/Wasser-Abwasser, Issue 36. 1967.

Mahlke, H. Ruckblick auf die INTAPUC-Fachausstellung in Paris (Review of INTAPUC Trade Exhibition in Paris).—Der Stadtetag, Issue 9. 1967.

Nebiker, J.H. Drying of Wastewater Sludge in the Open Air.—Journal Water Pollution Control Federation, Vol. 39, No. 4, Washington. 1967.

Palm, R. and R. Rasch. Mindestanforderungen an die Konstruktion von Müllverbrennungsanlagen fur kleinere und mittlere Gemeinden (Minimum Requirements for Designing Refuse Incineration Plants in Small and Medium Communities).—Schriftenreihe des Deutschen Arbeitskreises Wasserforschung e.V., Issue 14, E. Schmidt Verlag, Berlin. 1966.

Roediger, H. Schlammaufbereitung mit oder ohne Faulung? (Sludge Processing, with or without Digestion?).—Gas-und Wasserfach, Wasser/Abwasser, Issue 18. 1967.

Rohrer, E. Moglichkeiten der Schlammverwertung bei der Abwasserreinigung (Possibilities of Sludge Utilization in Wastewater Purification).—Chemische Rundschau, No. 36, 20th year. Solothurn. 1967.

Spohn, E. Das Kompostwerk Blaubeuren (The Blaubeuren Compost Plant).—Portland-Zementwerke Heidelberg AG. 1967.

Stalmann, V. Zur Eindickung von Abwasserschlamm (On the Thickening of Sewage Sludge).—Das Gas- und Wasserfach, Wasser/Abwasser, Issue 18. 1967.

Stickelberger, D. Einige Gedanken zum Problem des Sperrmülls und der geordneten Deponie (Some Thoughts on the Problem of Bulky Refuse and Controlled Tipping).—Stadtehygiene, 18th year, Issue 6. 1967.

Tanner, R. Le développement du procédé Von Roll pour l'incinération des ordures ménagères.—La technique de l'eau et de l'assainissement, No. 246, juin 1967, Bruxelles. 1967.

Triebel, W. and G. Peil. Die Schlammbehandlung auf dem Gruppenklärwerk des Niersverbandes (Processing of Sludge in Group Purification Plant I of the Niers Organization).—Gas- und Wasserfach, Wasser/Abwasser, Issue 18. 1967.

Wille, R. Zwei Jahre Müllzerkleinerungsanlage Neckarsulm (Two Years [Experience] with the Refuse Comminution Plant at Neckarsulm).—Der Stadtetag, Issue 8. 1967.

Wille, R. Die homogenisierte Mulldeponie in Neckarsulm (Homogenized Refuse Tipping at Neckarsulm).—Mull, Abfall, Abwasser, Issue 5, Verlag A. Schweiger, 516 Duren. 1967.

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Switzerland (German and French): Sekretariat der IAM, Physikstrasse 5, 8044 Zurich
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The Netherlands (German and French): Stichting "Compost," Jac. Obrechtstraat 67, Amsterdam-Z
Belgium (French): Service Communal de Belgique, Luxembourgplein 2 – 3, Bruxelles 5
France (French): Association Générale des Hygiénistes et Techniciens Municipaux, 9, rue de Phalsbourg, Paris 17e
Italy (Italian): Istituto di Ingegneria Sanitaria, Politecnico di Milano, Piazza Leonardo da Vinci 32, Milano
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Israel (German and French): Inter-Ministerial Committee for Utilization of Urban Refuse, Ministry of Health, Jerusalem
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